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The Blast Furnace *and* Steel Plant

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PRECEDENT

EARL BARNES, the well known lecturer on Psychology, recently warned us of the danger of too much routine. He suggests for instance varying one's path to and from the office, to lunch and to other places to which one may be obliged to travel, as by so doing, a tendency to habit formation is opposed.

Habit and Precedent are, from a certain viewpoint, synonymous. A Precedent may be formed in the same manner as a habit. While it is inadvisable in some cases to disregard Precedent, in others its observance is a hindrance. This is especially true in plant operation.

We are naturally inclined to follow the "path of least resistance", inasmuch as by so doing, we are compelled to digress less from our accepted practices. To deviate requires a greater expenditure of either mental or physical energy which is not sanctioned by our inherent laziness. Some people also have an in-born stubbornness that will not condone any change in adopted customs.

In many plants years of trial have established some methods or processes as productive of the highest results but there may be others that should be dispensed with, or altered, in order to secure greater returns in quality or quantity. If such methods or processes are maintained simply on account of Precedent, then Precedent should be scrapped.

Factors Affecting Open Hearth Refractories*

Certain Relations Between Refractories Service, Insulation, and Flow of Heat in the Open Hearth Furnace—An Investigation Conducted Under Operating Conditions

By B. M. LARSEN† and A. GRODNER‡

EVER since its first use as a steel-making furnace, the open hearth has nearly always been operated at temperatures very close to the melting point or softening range of the refractories used in roof arch, side wall, and port-end zones. For several years after Siemens developed the furnace, firebrick arches were used, and temperatures had to be closely regulated to make steel without serious softening and slumping of the brick. When silica brick was introduced for this purpose, the furnace could be operated at temperatures from 150 to 200 deg. F.§ higher than with firebrick. Operators soon raised operating temperatures up to the fusion point of silica brick, and ever since it has been common practice to push furnaces to the limit so that the inner layers of the silica brick are in a softened or fused state at more or less frequent intervals during steel-making operations. Most operators found by practical experience that the safety factor in operation was increased with decreasing thickness of walls, and that furnaces could be pushed harder and operated with less care without danger of serious damage to refractories. Although the walls and arches keep thinning down steadily during a campaign, the rate of wear tends to decrease as the walls become thinner.

Such operating conditions have naturally caused operators to picture the furnace as being essentially protected from destruction by air-cooling on the outside of thin walls. The statement is often made that thick walls or arches will wear back rapidly until they become thin enough to be protected by air cooling, after which the rate of deterioration becomes relatively slow. Such a picture often involves the idea that inner-wall temperatures are largely controlled by cooling from outside the furnace. Water-cooled surfaces are commonly placed outside certain zones where the brick are subjected to especially severe service conditions, to intensify the cooling effect of normal air circulation and free radiation.

The chief object of this paper is to outline a somewhat different picture of furnace conditions as they regulate wall temperatures and the wear of the refractories used in these walls. Although it may not be entirely accurate, such a picture seems to explain furnace conditions more rationally and is useful in considering the possibilities for insulation of the open-hearth structure.

*Published with approval of the Director, U. S. Bureau of Mines, Carnegie Institute of Technology, and the Metallurgical Board.

†Assistant Metallurgist, Pittsburgh Experimental Station, Bureau of Mines.

‡Research Fellow, Carnegie Institute of Technology.

§Degrees Fahrenheit used throughout this paper.

As so few accurate data on heat transfer coefficients at higher temperatures are available, there is less chance of error if conclusions are based largely on empirical measurements rather than upon calculations. As a result, such a discussion must be essentially qualitative in nature. Much of the material included here is given in a previous report,¶ based upon a study of service conditions of refractories in commercial open-hearth furnaces.

Mechanism of Wear on a Silica-Brick Arch During Service

If we disregard the effect of spalling, which is fairly well understood, the silica brick in an arch or wall are worn away by both fusion and slagging, two effects that are largely separate and independent of each other. The brick surfaces are continually bombarded by eddying gas currents carrying in suspension tiny oxide particles (composition about 80-90 per cent Fe_2O_3 , plus 5-15 per cent CaO) picked up from the bath. During the first week or two of service the new brick absorb these

oxide fluxes and become saturated and recrystallized in their inner zones. A brownish glaze forms on the inner roof surface, making the arch a good reflector for the radiant heat energy received from the flame.

During the remainder of the campaign the working refractory body of the roof is the recrystallized and flux-saturated inner zone of the brick, whose composition and structure is usually about as shown in Fig. 1. It has a fairly definite softening or fusion point, usually somewhere in the temperature range of 2,960 to 3,050 deg. It is composed of about 85-90 per cent of dense recrystallized cristobalite, with magnetite as the major impurity. As long as the furnace is held below a maximum temperature of about 2,975 deg., this material remains rigid, the roof does not drip or sweat by fusion of the brick, and the only wearing action on the brick is a slow fluxing of their surfaces by combination of the silica with iron oxide particles carried in the gases. The minimum temperature for this fluxing action seems to be at 2,600-2,700 deg., and occurs at all working temperatures of steel-making. Fluxing corrosion thus inevitably occurs in the latter portion of every heat, but fusion of the brick occurs only when all or a portion of the roof surface is heated above a maximum safe working range of 2,950 to 3,000 deg.

Temperature Changes in Roof and Walls

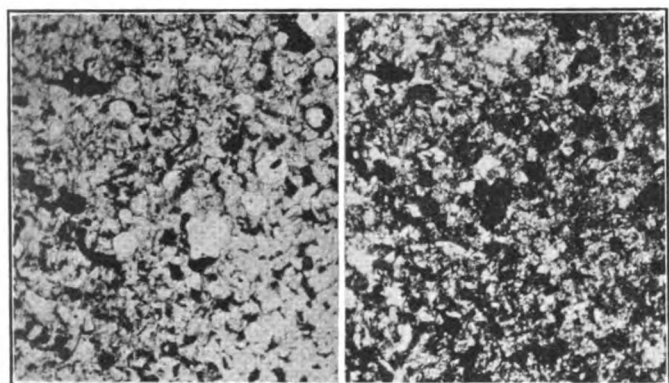
The curves in Fig. 2 were obtained by placing thermocouples at various distances as indicated from

¶Larsen, B. M., and Schroeder, F. W., "Service Conditions of Refractories for Open-Hearth Steel Furnaces." Bulletin 23, Min. and Met. Inv., Carnegie Inst. of Tech. and U. S. Bureau of Mines, 1925, 127 pp.

To secure the data on which this report is based, observations were taken at several open hearth plants in the Pittsburgh District. These observations, as far as conditions would permit, were then further checked at the Laboratory of the Bureau of Mines. For the completion of the work, a period of approximately one year was required.

EDITOR.

the inner surface of a 13½-in. roof in a large Talbot furnace, and taking temperatures over a period including two complete heats from the furnace. The couples were placed at distances of 0.6, 3.8, 6.9, and 10.1 in., respectively, from the inner surface, which was ordinarily 60 to 80 deg. hotter than the temperature registered by the innermost thermocouple. According to the temperatures, we should expect to



A.—Ordinary light.

B.—Crossed Nicols.

FIG. 1—Structure of recrystallized inner zone of silica brick from an open-hearth roof. Mainly cristobalite plus magnetite. Fusion point, cone 30, about 3020-3040°F.

Analysis, per cent

SiO ₂	86.3	CaO	0.8
Fe ₂ O ₃	6.5	MgO	0.6
FeO	5.1	MnO	0.4
Al ₂ O ₃	0.8	Total bases	14.2

find the roof surface "dripping" or fusing slightly in several periods near the end of each of these two heats, and this was actually the case.

Large temperature variations occurred during the period after tapping in each heat, during which the doors were opened and the flame cut off for 20 to 30 minutes to repair bottom and banks. The inner surface of the roof dropped from 800 to 1,000 deg. at these periods, while the outer zones of the roof varied in temperature less than 100 deg. The lag in temperature variations from inner to outer zones in the roof brick was from 1 to 2 hours. Such temperature fluctuations are shown more clearly by the temperature gradient curves in Figs. 3 and 4, for roof arches respectively 13.5 and 9.0 in. thick. The second furnace was being gently handled during this period and temperatures are somewhat lower than are normal in a sharp working furnace.

The melting chamber seems to cool down almost entirely by radiation out through open doors and by the cooling effect of cold air entering the chamber. The resultant rates of cooling, also the rates of heating when the flame is again turned on, are apparently large in comparison to rates of cooling by conduction through refractory walls. As a consequence, the variations in inner surface temperatures of roof arch and walls are controlled almost entirely from within the furnace, and seem to be largely independent of the thickness of roof or wall, even when these are as thin as 2 or 3 in.

Temperature Differences in the Melting Chamber

A long series of measurements were made in several different operating furnaces to find the ordinary differences in temperature between slag, wall, port,

and roof arch surfaces which occur especially during the finishing period of a heat. The differences between roof and side wall temperatures varied from 0 to 50 deg. and averaged about 14 deg. Apparently all of the brick surfaces of roof arch, side walls, and ports which are exposed directly inside the melting chamber tend to approach the same temperature throughout, through rapid interchange of radiant heat between surfaces. The slag surface of the bath was nearly always slightly cooler than the roof, but the difference found averaged only about 50 deg. Occasionally, near the end of a heat, the slag surface was found to be slightly hotter than the roof.

In general, two opposing tendencies affect the distribution of temperatures throughout the melting chamber. The variable rate of heat transfer to different surface areas by convection and the variable heat losses by conduction through various wall areas ordinarily tend to cause inequality of temperatures. Thus, a thin spot in a roof should be cooler than a thick area of side wall; the slag surface over a steel bath which is rapidly absorbing heat should be much cooler than a thick roof, and a wall or arch area near an impinging stream of flame gases should be hotter than areas at a distance from any flame zone. The interchange of heat by radiation, on the other hand, tends to even up the temperatures throughout the chamber, in opposition to the effects mentioned above. Suppose, for example, that a spot in the roof arch has been "burned" thin, so that more heat flows out of the chamber through this area by conduction: This increased conduction loss tends to lower the inner surface temperature of the thin roof area, but immediately the radiant heat exchange shifts in favor of this surface, tending to heat it up again to a temperature approaching that of the remainder of the

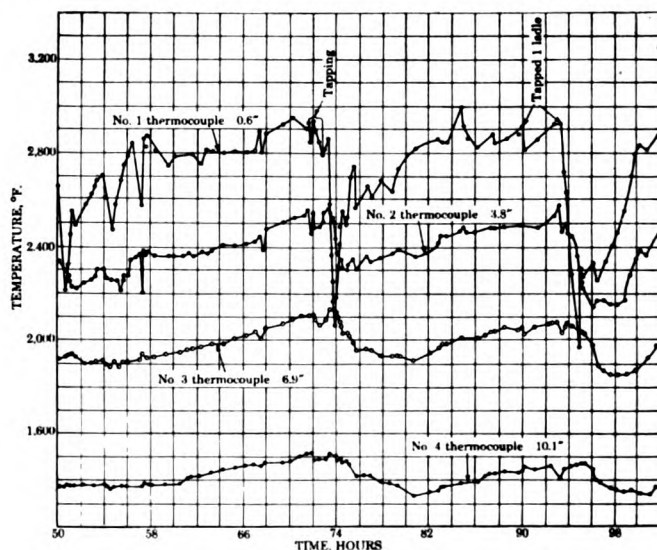


FIG. 2—Time-temperature curve of a Talbot furnace roof during two heats, silica brick.

chamber. The final difference in surface temperatures will grow smaller as the rate of radiation interchange of heat energy becomes more and more predominant over the rates of heat loss by conduction through the refractory walls.

In general, the rates of convection and conduction heat flow increase with the first power of temperatures and temperature differences involved, while radiation increases as the difference between the

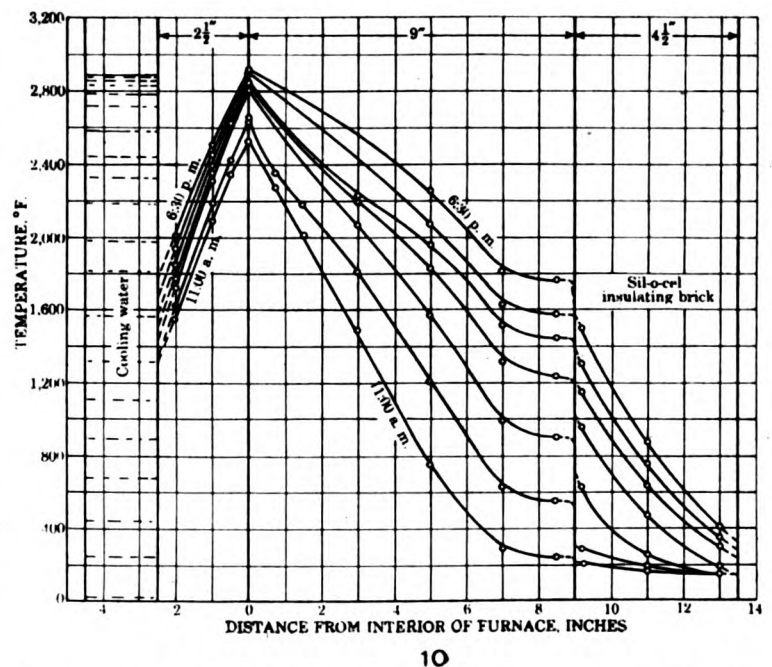
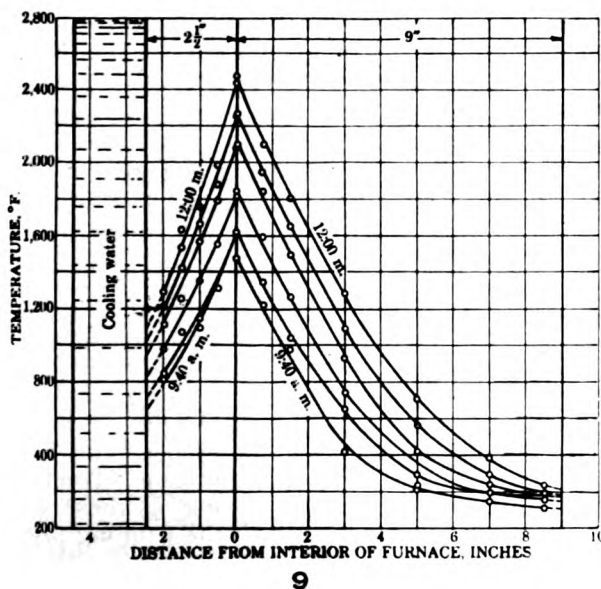
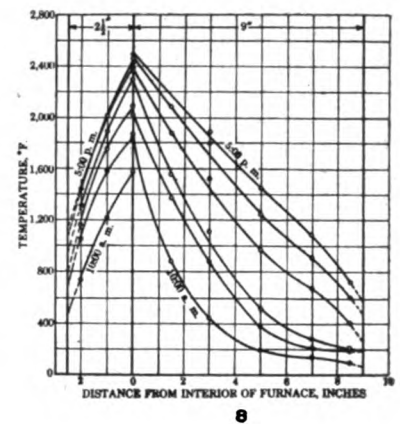
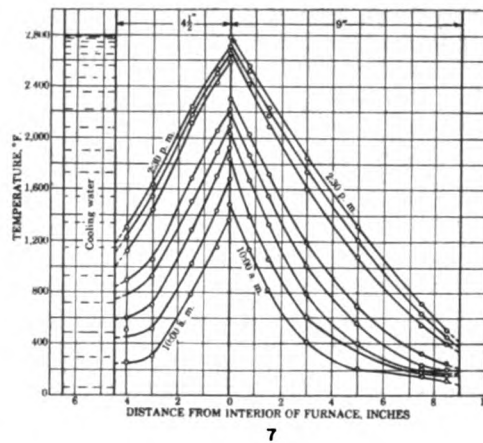
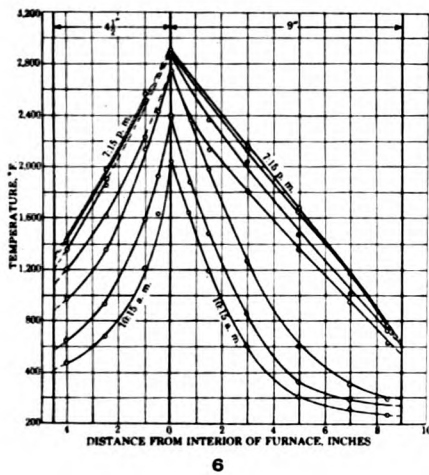
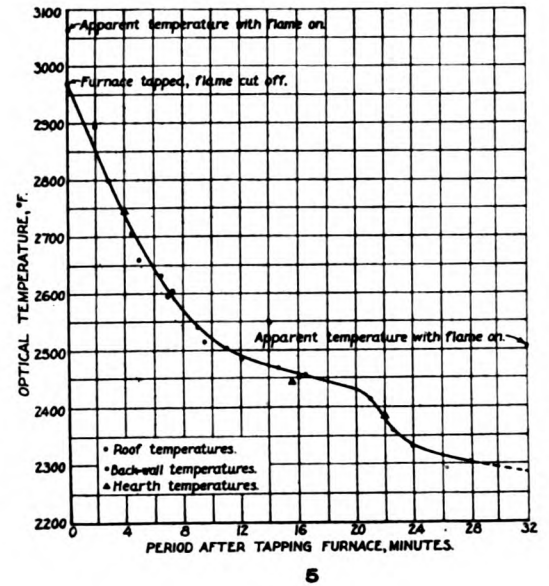
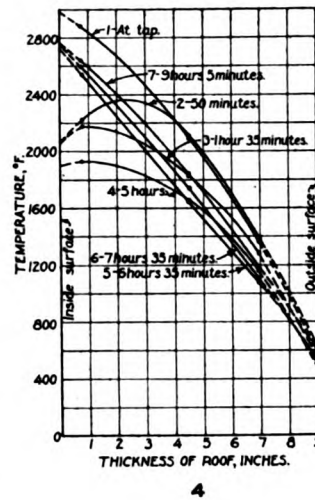
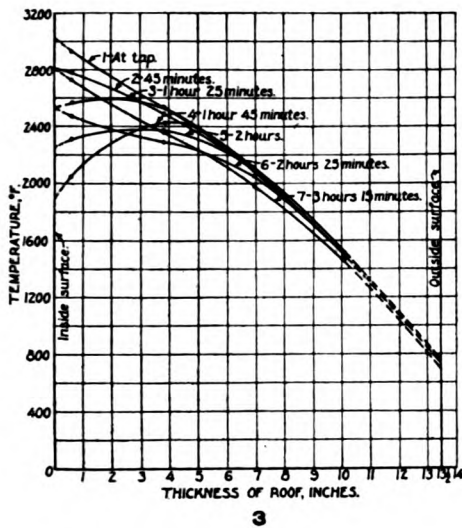


FIG. 3—Temperature gradient curves for roof of a tilting basic furnace, from tap to tap. FIG. 4—Temperature gradient curves for roof of a stationary basic open hearth furnace, from tap to tap. FIG. 5—Cooling curve of a melting chamber of an acid open hearth furnace during period between heats. FIG. 6—Temperature gradients through $4\frac{1}{2}$ " and 9" silica walls. FIG. 7—Temperature gradients through 9" silica wall and $4\frac{1}{2}$ " silica water-cooled wall. FIG. 8—Temperature gradients through $2\frac{1}{2}$ " and 9" silica walls. FIG. 9—Temperature gradients through 9" silica wall and $2\frac{1}{2}$ " water-cooled silica wall. FIG. 10—Temperature gradients through 9" silica wall insulated by $4\frac{1}{2}$ " insulating wall and $2\frac{1}{2}$ " water-cooled silica wall.

fourth power of the temperatures. At the high temperatures of steel-making we should expect to find radiation heat flow predominant, and a powerful tendency toward the maintenance of uniform temperatures throughout an open-hearth melting chamber.

The curve of Fig. 5 illustrates this tendency as it affects the rate of cooling of different surfaces in a melting chamber in the interval of bottom repair between heats. Temperatures taken on various roof, back wall, and hearth surface areas all fall very close to one cooling curve. The rapid radiation interchange between surfaces apparently causes the whole chamber to cool down as a close approximation to a black body.

Comparative Temperature Gradients in Various Walls

The gradient curves of Figs. 6 to 10 also indicate the same tendency of radiation interchange to maintain uniformity of surface temperatures throughout a high-temperature furnace chamber. These curves were obtained by placing thermocouples in opposite walls of a small laboratory furnace chamber about 15 by 15 by 18 in. in size. This chamber was heated entirely by radiation from a graphite pile resistor carrying an electric current. Inside surface temperatures were measured directly by a platinum thermocouple placed along the inside surface in a silica protection tube. The outside surface temperatures are determined approximately by extrapolation through $\frac{1}{2}$ -in. brick layer. Fig. 6, 7, 8, and 9 show gradients in 9-in. air-cooled silica walls compared with $4\frac{1}{2}$ -in. and $2\frac{1}{2}$ -in. walls, both air-cooled and water-cooled, (by a sheet-tank in contact with the outside surface). Fig. 10 gives comparative gradients in a 9-in. silica wall insulated with $4\frac{1}{2}$ in. of sii-o-cel and a $2\frac{1}{2}$ -in. water-cooled silica wall.

In all cases, the inside surface temperatures in opposite walls seem to approach equality as furnace temperatures approach 3,000 deg., even the $2\frac{1}{2}$ -in. walls being only 20 to 40 deg. cooler than the 9-in. walls at the higher temperatures (2,800-2,900 deg.).

Thermal Efficiency and Heat Losses

According to Dyrssen,* the net thermal efficiency (based on heat from fuel only) for various open hearths varies in the range of 1 to 15 per cent. This efficiency varies also during the course of a heat. Assuming an average efficiency of 4 per cent for a given furnace, then during the charging and early melting periods, when the relatively cool charge is absorbing heat rapidly, the net efficiency may be up to 10 to 20 per cent.

During the heat, this efficiency gradually drops, as the charge comes up nearer to the temperatures of roof and wall surfaces and of the flame itself. Some heat (perhaps 10 to 15 per cent of the total) is also generated by chemical reactions within the bath itself, most of which is used in useful work in the bath. Near the end of a heat the net thermal efficiency in many furnaces very probably drops to zero. Under these conditions, 40 to 50 per cent of the heat from the flame is going to the stack as waste gases; the remainder of 50 to 60 per cent, including all of the high-temperature heat, is being used to make up for the enormous heat losses to cooling water, by radiation through doors and by conduction through the thin, air-cooled walls of the whole furnace structure.

*Dyrssen, W., "Recovery of Waste Heat in Open-Hearth Practice." Jour. Iron and Steel Inst., vol. 102, 1924, pp. 175-255.

Especially in certain processes like the Talbot process, with a high percentage of hot metal used, the essential function of the flame is almost entirely that of keeping the furnace walls up to temperature rather than that of heating the bath.

(To be continued)

1926 Fuel Saving Greatest Ever

Greater efficiency than ever before in the use of fuel by road locomotives was accomplished by the Class I railroads in 1926, according to reports for the year just filed by the railroads.

An average of 137 lbs. of fuel was required in 1926 to haul 1,000 tons of freight and equipment, including locomotive and tender, a distance of 1 mile. This was the lowest average ever attained by the railroads since the compilation of these reports began in 1918. The best previous record was established in 1925 when the average was 140 lbs.

Passenger Service Sets Record

Record efficiency in the conservation of fuel was also shown for the passenger service, the average amount for the year used in that service having been 15.8 lbs. to move each passenger train car a distance of 1 mile. The best previous low record for this service was in 1925, for which the average was 16.1 lbs. In 1920, the average was 18.8 lbs.

Class I railroads in 1926 utilized for road locomotive fuel 101,007,549 tons of coal and 2,067,272,099 gallons of fuel oil. In each instance, these amounts were somewhat greater than in 1925. This increase in the aggregate consumption of fuel was due wholly to the increased traffic handled.

Fuel Economy Increasing Steadily

There has been a steady increase in the conservation of fuel on the part of the railroads of this country since 1920. In part this has been due to the construction of improved locomotives built with a view of increasing the tractive power while at the same time reducing the amount of fuel needed to operate them. Educational programs have also been carried on by the railroads to instruct firemen as to the proper method of stoking locomotives and to encourage fuel conservation.

Lincoln Arc Welding Prizes

The American Society of Mechanical Engineers has accepted the custody of \$17,500 given by the Lincoln Electric Company of Cleveland, Ohio, U. S. A., to be awarded, under the rules of the competition, to those contributing the best three papers disclosing new information that will tend to advance the art of arc welding.

Purposes of the Competition—The purpose of this competition is to encourage improvements in the art of arc welding, the pointing out of new and wider applications of the process, or indicating advantages and economies to be gained by its use, as these latter will be the chief bases upon which the winning papers will be selected.

The \$17,500 will be awarded as follows: First prize, \$10,000; Second prize, \$5,000; Third prize, \$2,500.

Address all communications to The American Society of Mechanical Engineers, Calvin W. Rice, secretary, 29 West Thirty-ninth Street, New York City, U. S. A.

Selection of Motors and Controllers

An Analysis Is Made of Motor Operation and Requirements Under Varying Loads and Speeds—Other Factors Analyzed Are Ventilation Efficiency and Cost

By GORDON FOX*

PART II

OF interest also is the static torque which must be overcome in starting the machine from rest. Just as the demand during a cycle may vary, so the static torque may vary depending upon the point in the cycle at which the machine is started. The static torque may involve friction only if the machine starts light or performs no work until speed is attained. On the other hand starting torque may involve elements of useful load and particularly inertia load. Static torque and running torque may be closely similar or widely differing depending upon static and running friction and character of load. The static torque of a given machine may be determined by attaching a lever and weight or spring scale to a shaft or pulley and measuring the torque necessary to start movement.

The manner in which the load builds up as a machine accelerates may have an important bearing. For instance a centrifugal fan has little friction load and starts very easily. Acceleration involves an element of inertia load of some magnitude. As the fan acquires speed the useful load comes into play. As a result of the combination of elements the current required by the motor during the starting period will be maintained or increased whereas in the more common case, the current during acceleration decreases. This action may have an influence on the motor. Particularly in the case of synchronous motors this holds true as the static torque and pull-in torque must be properly related with respect to the load characteristics. In general, these starting considerations are of particular importance in determining control layout.

When the load imposed by a driven machine is steady and continuous it serves as a direct measure of motor capacity required. When loads vary or fluctuate, the condition is more complicated. Loads may fluctuate in a regular manner through a cycle of values, as in a metal planer where reversing, cutting and return stroke periods impose differing demands. Loads may fluctuate in irregular manner as in the case of a grinding wheel or rock crusher. Figs. 3 and 4 show typical cycle and irregularly fluctuating loads. The great majority of loads are subject to changes brought on by different materials handled or different details in operations performed from time to time. In the case of adjustable speed, multispeed or varying speed motors it is desirable to consider what load changes are caused by changes in speed. In the case of a printing press or conveyor in which the load is largely friction, the torque will usually remain approximately constant at all speeds and the horse power demand will increase about in direct proportion to the speed. This is called a constant torque drive and the motor must exert its maximum power at its maximum speed point. In a rolling mill where heavy sections are rolled at the lower speeds and lighter sections at the higher speeds the horse power demand may be ap-

proximately the same for all speed points. The load demand of a centrifugal fan increases about as the cube of the speed so that the load at low speeds is comparatively light. These are but a few examples of load characteristics which should be considered as bearing on motor and control selection.

Relation of Load to Motor Size

The aim in motor application is to supply a motor which will meet every requirement of the load demand without punishment, yet without excess investment

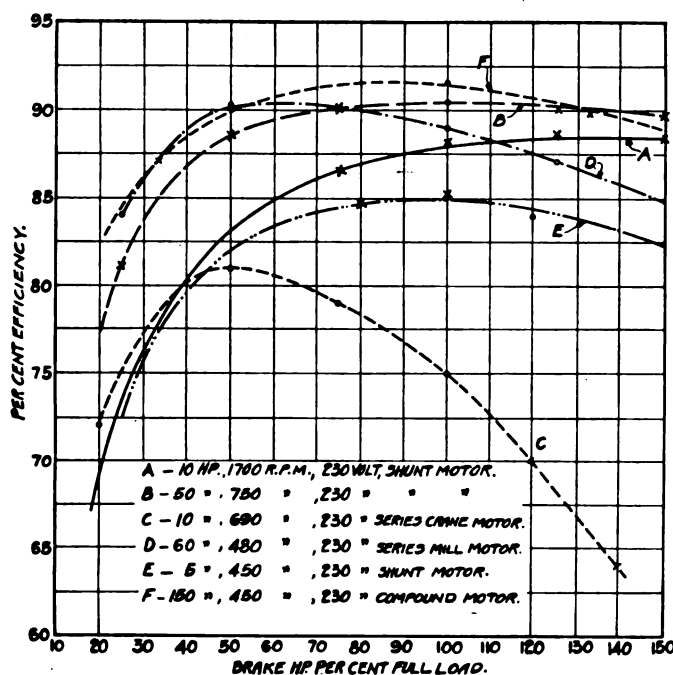


Fig. 2

FIG. 2—Efficiency-load curves of d.c. motors.

and which will operate under prevailing conditions with best efficiency and to best general advantage. Where a load is subject to variation it is necessary to determine or approximate:

The normal load conditions and the extent of deviation therefrom.

The maximum load requirement and the period of such demand.

The average or effective load on the motor due to summation of varying momentary demands.

Root Mean Square Method of Motor Size Determination

The capacity of a motor is determined in part by its heating. This in turn depends upon the rate at which losses within the motor release heat energy and the rate at which this heat is radiated or conveyed from the motor surfaces. The losses in a motor comprise two elements namely, those which are more or

*The Freyn Engineering Company.

less constant, such as magnetization, friction and windage, and those which vary with the load, such as copper loss. Due to the fact that copper losses (I^2R) are proportional to the square of the load current, it is commonly considered that the heating is about pro-

portional to the root mean square current, that is, the square root of the sum of the squares of momentary current values, taking into consideration the duration of these values. The rating of a motor required for a given duty is therefore often determined on the basis

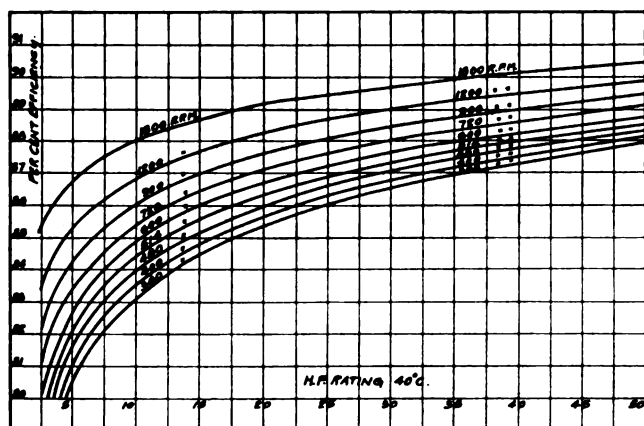
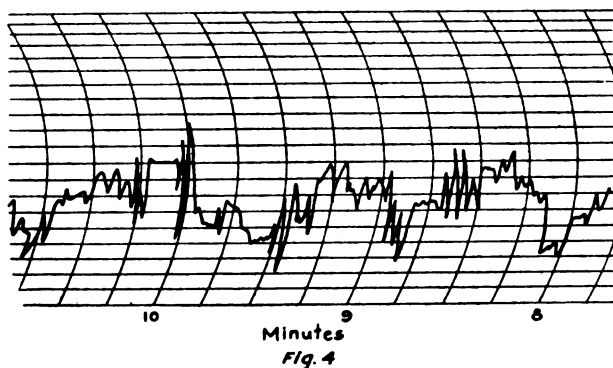
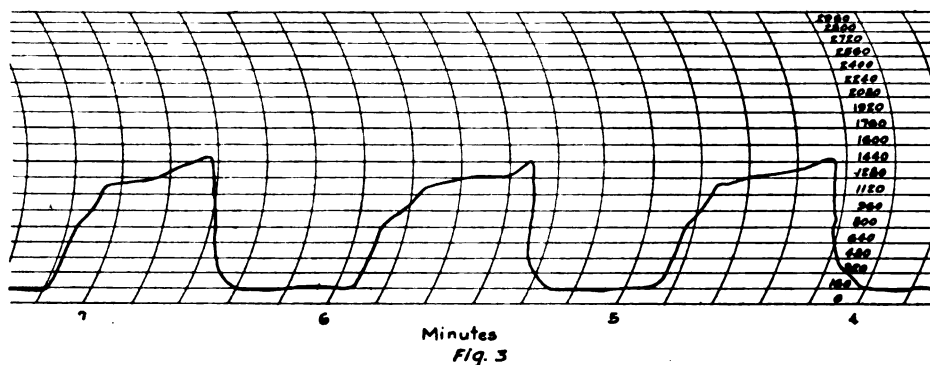


Fig. 6

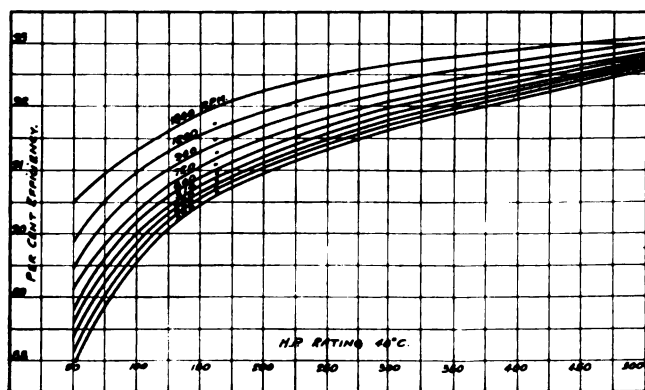


Fig. 7

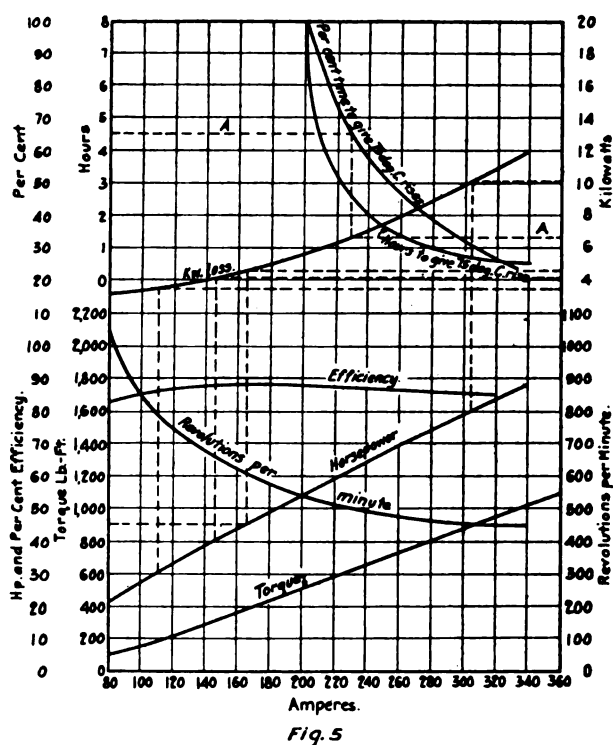


Fig. 5

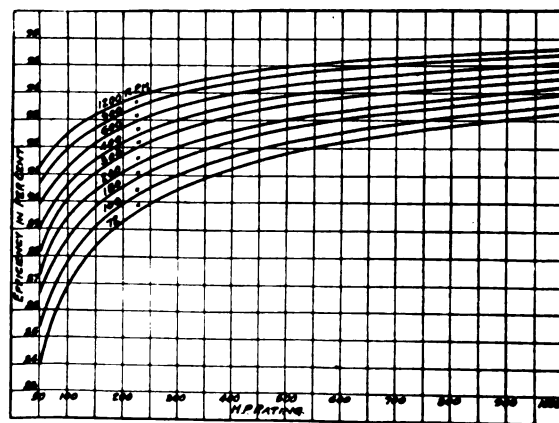
FULL LOAD EFFICIENCY OF SYNCHRONOUS MOTORS
OPERATING AT 100% POWER FACTOR.

Fig. 8

FIG. 3—Load on motor driving continuous roughing rolls in steel mill. Typical cyclic load. FIG. 4—Load on motor driving finishing rolls in steel mill. Typical fluctuating load. FIG. 5—Characteristic curves of a motor for bucket hoist. FIGS. 6 and 7—Full load efficiencies of squirrel-cage induction motors. FIG. 8—Full load efficiencies of synchronous motors.

of the r.m.s. (root mean square) current. Where power and current are approximately proportional, the motor horse power required may be based on the r.m.s. value of power.

In determining motor size by r.m.s. method the fact must be considered that when the motor is at rest or running very slowly, it does not dissipate heat as rapidly as when running at normal speed. Therefore, in cycles of operation which include rest periods, it is necessary to discount for the decreased rate of heat dissipation. It is usual to consider that the cooling rate at standstill is about one-half to one-third of the full speed value so that, in taking the time of a cycle to determine the average heating, only one-half or one-third of the rest period is considered. It is commonly considered that an open type motor will dissipate at standstill one third that when running. An enclosed motor will dissipate at standstill one-half the heat dissipated when running. The practice is frequently followed to consider the cooling rate at standstill as one-quarter that when running and to consider the cooling rate during acceleration and deceleration periods as one-half that when running full speed.

This general method of motor selection may best be shown by an example. Let us consider the case of a grab bucket hoist involving the following load cycle:

Action	Period	Output
Close bucket	6 sec.	40 hp
Hoist	10 sec.	80 hp
Open bucket	3 sec.	30 hp.
Lower bucket	10 sec.	45 hp.
Rest	16 sec.	

The r.m.s. load =

$$\frac{(40^2 \times 6) + (80^2 \times 10) + (30^2 \times 3) + (45^2 \times 10)}{29 + \frac{16}{3}} = 53 \text{ horse power.}$$

According to this calculation, a motor having a continuous rating of 53 hp. would handle the above bucket performing its cycle in continuous repetition.

Due to approximations as to variation of losses with load and variation of heat dissipating ability, the r.m.s. method of selecting motor size is not entirely accurate. However, the data upon which the calculations are based, is usually more or less approximate, justifying the method. For some motors of standard designs, data is available for computation of motor size by the loss method. This is done by comparing the losses with the heat dissipating ability of the motor. This method may be best shown by an example which will consider the bucket hoist previously mentioned. Fig. 5 shows the characteristic curves of a motor suitable for this work and of size known to be approximately correct. The ability of the motor to handle the load will be checked.

Action	Period	Output	Watts loss from curve	Watts lost $\times$ seconds
Close bucket .	6 sec.	40	4,200	25,200
Hoist	10 sec.	80	10,400	104,000
Open bucket .	3 sec.	30	3,500	10,650
Lower	10 sec.	45	4,650	46,500
Rest	16 sec.	0	0	0
Total	45 sec.			186,350

The values of watts lost corresponding to horsepower output are taken from motor curves. The total run-

ning time is $6 + 10 + 3 + 10 = 29$ seconds. The average loss while running is $186,350 \div 29 = 6,420$ watts. From the motor curves it may be found that 6,420 watts loss per second while running will not heat the motor above 75 deg. C. rise provided the running time is not more than 65 per cent of the total time. In the above case the running time is $29 \div 45 \times 100 = 64$ per cent of the total time. Therefore the motor will not overheat under this duty continuously repeated. This motor has a continuous rating of 55 hp., which checks quite closely the previous calculation on r.m.s. basis.

In many cases, particularly when load fluctuations are not severe, the motor size may be based on average load. This method is particularly convenient in making a test wherein the average load may be determined from the power consumption for a given period as determined by watt hour meter, this value being translated into motor output by correcting for average motor efficiency.

If a motor is called upon to retard, as by dynamic breaking or plugging these factors must be taken into consideration as they have a material influence on motor heating.

Continuous and Intermittent Ratings

Motors which are intended for fairly continuous duty at approximately full load, are continuous rated. Such motors are not intended to develop or handle mechanically, loads greatly in excess of their rating based on continuous duty heating. Where the service of a motor is intermittent it is not necessary that the motor be able to dissipate continuously, losses developed during short intervals of operation. So called "intermittent duty" motors are so designed that they are capable, both mechanically and electrically, to develop powers in excess of their continuous heat dissipating ability. Intermittent ratings are based on the period of time during which a motor will develop full load and attain a given temperature rise in so doing. Based on 75 deg. rise the motor whose characteristics are shown in Fig. 5 might be rated at 93 hp. for 30 minutes, 75 hp. for 60 minutes or 65 hp. for 120 minutes. This motor might also be used for continuous service, in which case it would develop 55 hp. with 75 deg. C. rise. It will be seen that, if a motor of this type is used for continuous service its full mechanical and electrical capabilities are not realized due to the restriction placed by heating. More effective use of the motor might then be made through use of artificial cooling which might permit the motor to develop continuously perhaps 75 or 80 horsepower.

The requirements of driven machines in the matter of speed are varied indeed. In an occasional instance speed is zero, that is, the motor produces torque only and moves through a very small angle. The great majority of machines require more or less continuous operation at an approximately constant speed. In some cases very close constancy or accuracy of speed is required, as for some textile drives and for paper machines and notably for such uses as mechanical rectifiers and synchronous motor driven clocks. Somewhat less common are the machines requiring adjustable speed, namely, a constantly maintained speed at selective values. Where adjustable speed is desired, the range may be either narrow or wide. More commonly a range of two to one or four to one, covers the requirements. Sometimes the range may be much greater. In the case of adjustable speed it may be

desired to have particularly good regulation over a given portion of the range. Multispeed is used to designate practically constant speed operation at a few definite values with little or no adjustment between these values. The multispeed motor does not fulfill any requirement which the adjustable speed motor cannot meet, but is used because of its availability for a.c. circuits. Most manipulating and traction drives require motors with varying speed characteristics capable of developing high torques at low speeds and lesser torques at higher speeds.

There may or may not be a choice in the speed rating of a motor for driving a given machine. Where direct connection is feasible it is usually although not always desirable. The motor speed is then dictated by the machine requirements. With gear, chain or belt drive there may be a choice in motor speeds. Primarily the speed selected must be such as to give good mechanical drive conditions. Within limitations of motor performance and mechanical practice it is usually desirable to utilize as high a motor speed as feasible as the first cost of the motor is thereby decreased. Both the efficiency and the power factor of induction motors are better at the higher speeds.

Alternating-current synchronous motors and induction motors are limited to definite synchronous speeds as determined by the number of poles per phase in the primary winding. Table III shows the range of synchronous speeds for both 60 cycle and 25 cycle motors. Approximate full load speeds of standard squirrel-cage motors are also shown. It will be noted that 60 cycles affords a greater range and choice of motor speeds.

TABLE III
Synchronous Speeds and Approximate Full-Load Speeds for 60-Cycle and 25-Cycle Induction Motors

Number of poles	60 Cycles		25 Cycles	
	Synchronous speed	Full-load speed	Synchronous speed	Full-load speed
2	3600	3450	1500	1440
4	1800	1740	750	720
6	1200	1150	500	480
8	900	860	375	360
10	720	690	300	285
12	600	575	250	240
14	514	490	215	205
16	450	430	187	180
18	400	380		
20	360	340		
24	300	285		
30	240	230		

For reasons of interchangeability the Electric Power Club has standardized speed ratings for standard general purpose d.c. constant speed motors to correspond closely with full-load speeds of 60 cycle squirrel-cage motors. Table IV lists these standard horsepower and speed ratings. D.c. constant speed motors are obtainable at other horsepower and speed ratings, but they are more or less special. Aside from mechanical limitations which restrict the larger high speed motors to direct connected service, the writer considers that 1,150 rpm. may well be considered maximum for constant speed d.c. motors above 25 hp. and 850 rpm. for similar motors above 50 hp., as the higher speed motors are more prone to commutation difficulties.

Enclosure or Protection

Motors may be classified as to the degree of protection afforded to the working parts. The Electric

Power Club has adopted certain terminology for various types of protection.

Drip-proof apparatus will exclude falling moisture or dirt. This implies total enclosure of the upper half of the motor.

Dust-tight apparatus is so constructed that dust will not enter the enclosing case. Total enclosure is presumed to meet this requirement, but many such

TABLE IV
Horsepower and Standard Speed Ratings for Constant Speed General Purpose D.C. Motors

Hp.	Rpm.	Rpm.	Rpm.	Rpm.
1	1750	1150	...	...
1½	"	"	...	...
2	"	"	...	...
5	"	"	850	...
7½	"	"	"	...
10	"	"	"	...
15	"	"	"	...
20	"	"	"	575
25	"	"	"	"
30	"	"	"	"
40	"	"	"	"
50	*1750	"	"	"
60	"	"	"	"
75	"	"	"	"
100	"	"	"	"
125	"	*1150	"	"
150	"	"	"	"
200	"	"	"	"

*Suitable for direct connection only.

motors leak dirt where the covers fit the frame. Where dirt and dust conditions are severe, the writer recommends the use of gasketed covers.

Gas-tight apparatus is so enclosed as to exclude the surrounding atmosphere. Total enclosure with gasketed covers is required.

Splash-proof apparatus is protected from the entrance of spray from any direction. Ordinary full enclosure meets this requirement.

Submersible apparatus must be capable for immersion. Complete, gasketed enclosure and special construction are involved.

Weather-proof apparatus is protected against exposure to weather. This implies more or less total enclosure.

An enclosed machine is defined as such that the circulation of air through its interior is prevented. This does not imply air tight construction.

A semi-enclosed machine is defined as being provided with perforated covers.

As these various classifications do not specify definitely the extent and type of covers provided, the writer considers that, in many instances, it is preferable to specify:

- Enclosure both ends or one end.
- Total or semi enclosure upper half.
- Total or semi enclosure lower half.
- Use of gasketed covers if required.
- Type of bearings and protection desired.
- Special requirements.

The enclosure of a motor reduces its heat dissipating ability. As affecting the rating, motors may be considered as open, semi-enclosed, enclosed and enclosed-ventilated types. General purpose constant speed open motors are rated on the basis of 40 deg. C. rise with continuous duty. Semi-enclosure may necessitate a reduction in rating or the open rating may hold on a 50 deg. C. basis, depending upon the specific case. Totally enclosed general purpose motors are

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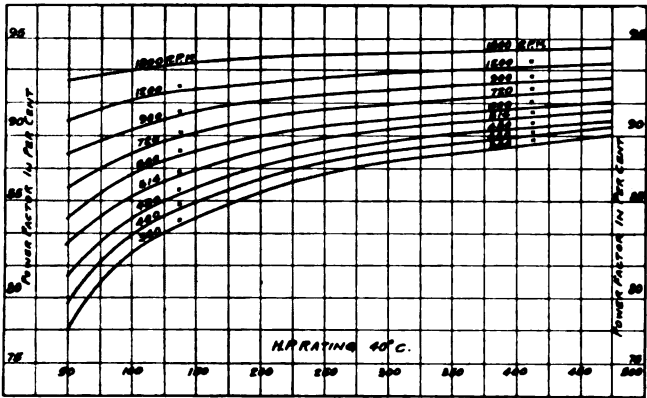


Fig. 9

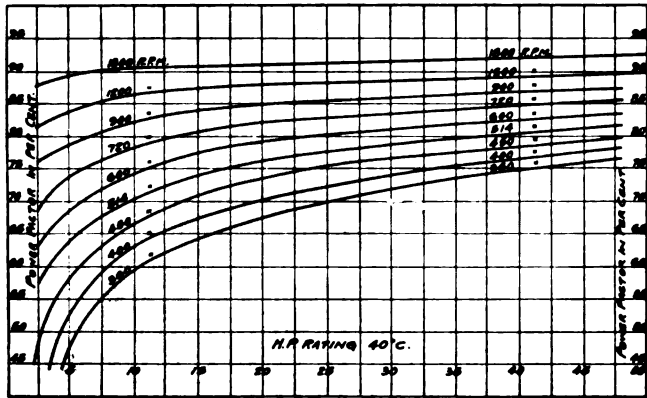
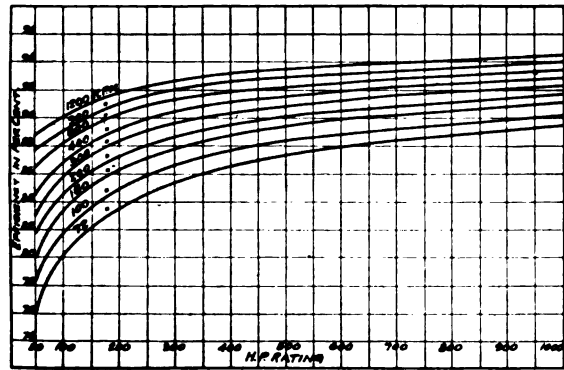


Fig. 11



FULL LOAD EFFICIENCY OF SYNCHRONOUS MOTORS
OPERATING AT 80% LEADING POWER FACTOR

Fig. 12

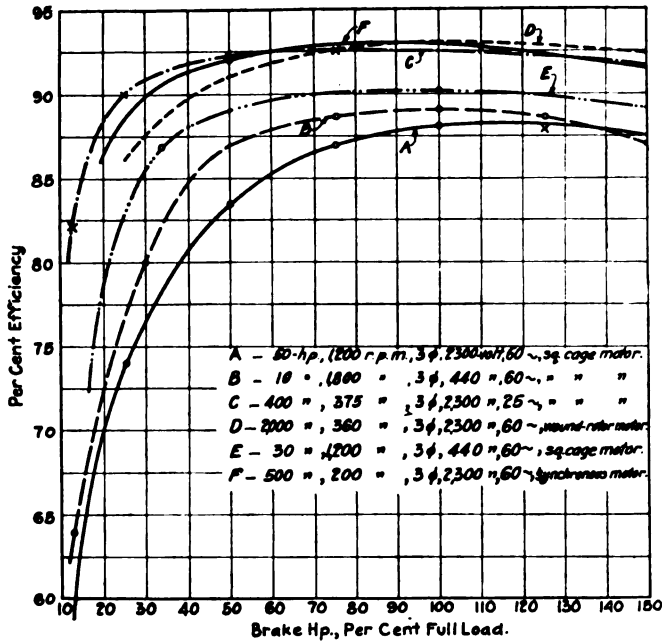


Fig. 10

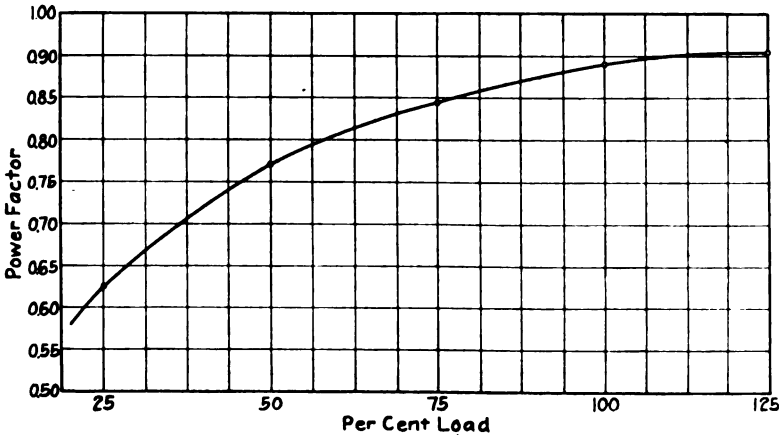


Fig. 13

FIGS. 9 and 11—Power factor of low speed motors. FIG. 10—Efficiency load curve of a.c. motors. FIG. 12—Full load efficiencies of synchronous motor. FIG. 13—Variation of power factor with load in 60 cycle induction motor.

rated on a 55 deg. C. rise basis. Enclosed mill type, crane type and railway type motors provided with class B insulation are rated on a 75 deg. C. rise basis. This temperature rise may apply to continuous or short time duty, the time basis of rating being stated.

An enclosed motor requires about 2 to 2.5 sq. in. of motor surface per watt loss to maintain 55 deg. C. temperature rise with continuous service. In the case of small motors, the external surface of the frame is comparatively large so that an enclosed rating can be obtained approaching the open rating. The frame surface per horsepower decreases rapidly as the size increases so that enclosure becomes less economical for the larger ratings. The external surface for a given horsepower is greater on slow speed, than on

high speed motors. Thus the slow speed motor may be enclosed with less effect on its rating. The economical field of the totally enclosed general purpose motor is limited to the smaller ratings, preferably below 25 horsepower.

Forced-Ventilated Motors

In forced ventilated motors air is passed through the motor and some external piping by means of a blower which may be either self-contained or separately driven. When a ventilated motor is supplied with a proper amount of air, the losses may be cared for as well as in an open motor, hence a given frame will deliver an output comparable to its open rating. The rating developed by a forced ventilated motor

depends largely upon the amount of air passed, a condition which may be advantageous.

Safe temperatures in forced-ventilated motors are dependent upon a sufficient proper and maintained air supply. Excess pipe friction should be avoided. Ordinarily the ventilating pipes should not exceed 25 ft. in length and the air velocity should not exceed 1,000 ft. per min. The air should be taken from a clean, cool location.

Self-forced ventilation is feasible on the higher speed motors only, say 700 rpm. and above, due to limitations in the space available for the fan. Enclosed ventilated motors, otherwise equal, cost 5 to 10 per cent more than open motors of the same rating. The power taken for ventilation is usually less than 1 per cent of the motor rating.

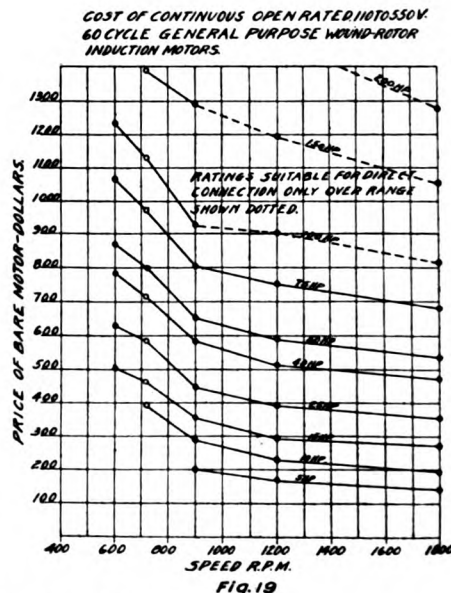
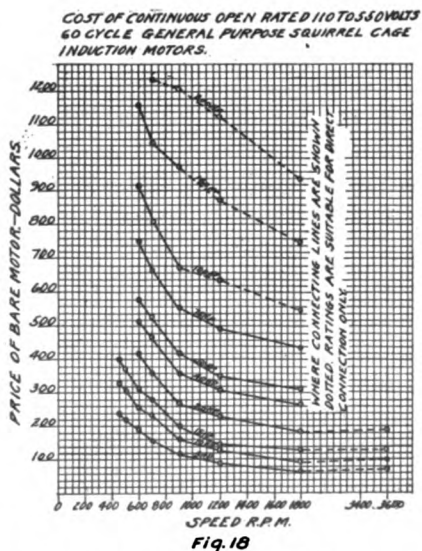
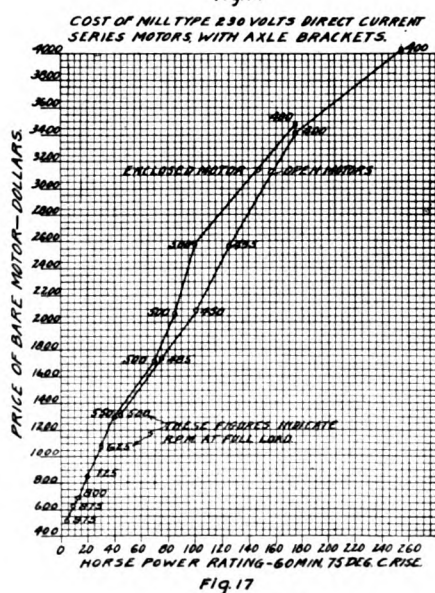
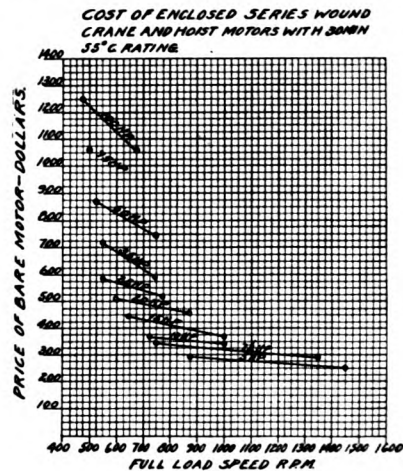
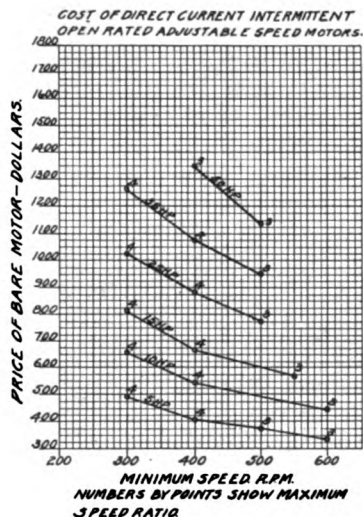
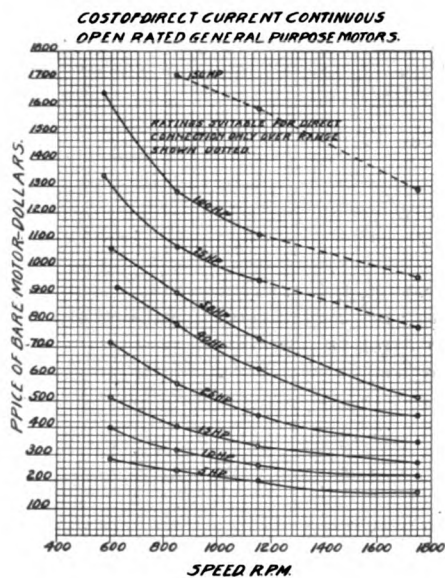
It is the writer's opinion that the extensive use of enclosing or protecting covers is warranted wherever motors are exposed to moisture, dirt or mechanical injury, particularly wherever current collection is involved. Where extensive total enclosure is required, the economies incident to the use of forced-ventilation should be considered.

When motors are installed at altitudes in excess of 3,000 ft. the motor rating should be discounted $\frac{1}{2}$ per cent to 1 per cent for each 300 feet in excess of this altitude.

Several types of motor construction have been developed to meet the mechanical requirements of specific fields of motor application. The prevailing type is the general-purpose motor, a competitive design of rather light construction adapted for industrial service where requirements are not severe. Among other types may be mentioned crane and hoist motors, mill type motors, mine type a.c. motors, railway and mine railway motors, vertical motors and other special constructions. There is some tendency to use the general purpose motor in places where other more substantial types might be preferable. This is largely due to the lower first cost and the greater availability of the general purpose motor. It is well to consider the feasibility of the different motor types before making a selection.

Efficiency

The question of motor efficiency is of some importance. A reliable and effective drive is essential.



FIGS. 14 to 19—Cost of motors with characteristics as noted at top of figure.

Efficiency is secondary but not negligible. A motor which has two or three points advantage in efficiency may save a worth while margin in power consumption. Load factor or utilization factor plays a determining part. If a motor is seldom used and but lightly loaded, a given margin of efficiency leads to a lesser saving than in the case of a motor steadily driving and well loaded. The question of efficiency is particularly pertinent as applied to the larger motors for such equipment as fans or compressors. The margin in first cost justified by increased efficiency may be approximately computed in any case.

The influence of motor speed upon motor efficiency should be noted. In the case of d.c. motors there is no direct relation although the moderate speed motors appear, in general, to show a slight advantage. In the case of a.c. motors, notably induction motors, the higher speed machines are the most efficient. This will be seen from Figs. 6 and 7 which show full-load efficiencies of a line of squirrel-cage induction motors.

At the higher speeds induction motors and synchronous motors will generally compare closely in efficiency. At the lower speeds the synchronous motor, particularly if operated near unity power factor, will generally be superior in efficiency. Figs. 8 and 12 show full-load efficiencies of synchronous motors.

The efficiency of a motor is usually highest at about full load. There is, therefore, a considerable measure of advantage in operating a motor under sufficient load to realize good economy. A grossly over-size motor carries a penalty, not alone in fixed charges, but also in excess power consumption. The variation of efficiency with load is shown in Figs. 2 and 10 giving typical efficiency curves for several types of d.c. and a.c. motors.

In the case of motors which are subject to frequent starting and stopping as in traction or steel mill auxiliary service, overall efficiency should be considered rather than motor efficiency alone. The resistance losses are usually of greater magnitude than the motor losses. Resistance losses can be minimized through the use of the proper gear ratio and most advantageous control.

Power factor is receiving ever greater consideration. Poor power factor penalizes both the capacity and the efficiency of generating, transforming and distributing equipment. The influence on distributing investment and distributing economy is felt in almost every plant using induction motors. The influence on investment, economy and voltage regulation of generating and transforming equipment is felt by motor users in varying degrees dependent upon whether power is generated or purchased and upon what rate basis. The trend is ever stronger, however, to pass along to the motor user the excess costs associated with wattless current demand.

Low power factor is likely to prove to be a particularly serious consideration under the following circumstances:

Where most of the motors in a plant are induction motors.

Where many individual drives are used, involving a multiplicity of small motors, each having marginal load capacity, usually underloaded and demanding, in combination, a large magnetizing current.

Where slow speed induction motors are used.

Where little or no load of inherently high power-factor or corrective ability can be combined with the induction motor load.

Where power is generated by the user or where the purchase rate carries a power-factor clause.

The power factor of the induction motor is highest under load as the magnetizing current remains approximately constant while the load current increases. Fig. 13 shows the variation of power factor with load in a typical 60 cycle induction motor. It is evidently desirable that the operation of induction motors at very light loads is to be avoided, where possible, because of the influence on power factor. The power factor of low speed motors is lower than that of high speed motors due to the higher magnetizing current required. It will be seen in Figs. 9 and 11 that the power factor of the low speed motors is relatively poor.

The induction motor is the offender mainly responsible for the power factor bugaboo. Its simplicity, reliability, low cost and suitability in many cases, lead to its common selection. Largely because of its ability to operate with high or leading power-factor the synchronous motor is becoming more popular and its performance is being steadily improved. It is suggested that all continuously running drives of larger size should be carefully considered as possible applications for the synchronous motor.

Cost Considerations

Insofar as the desired results can be attained without sacrifice it is always desirable that the first cost of a motor drive installation be minimized or kept within moderate limits. In accomplishing this result the cost of the motor should not be considered alone. The cost of the entire drive, including control and mechanical transmission media must determine.

Figs. 14 to 21 inclusive and Table V show approximate costs of several of the more commonly used types

TABLE V

Cost of Mine Type, Enclosed Ventilated, Continuous Rated, 40-Deg. C., Squirrel Cage Induction Motors

Horsepower	Full load speed	Cost of bare motor
7½	845	\$ 425
10	845	465
	565	650
15	860	585
	565	700
20	865	650
25	865	720
	565	965
35	570	1,060
40	870	1,040
50	870	1,125
	575	1,185
75	875	1,280

and sizes of motors. Prices are for motors without base, pulley or starting device. Prices are net retail as of February 1927. The prices given are by courtesy of the General Electric Company.

The tendency to purchase motors and controllers largely on a price basis will be ever with us. In view of this fact too much emphasis can hardly be placed upon the advisability of a broad viewpoint. Motors, in general, are important primarily in the influence their stoppage or disability may have upon production or whatever service is rendered by the driven machine. This is particularly the case where processes

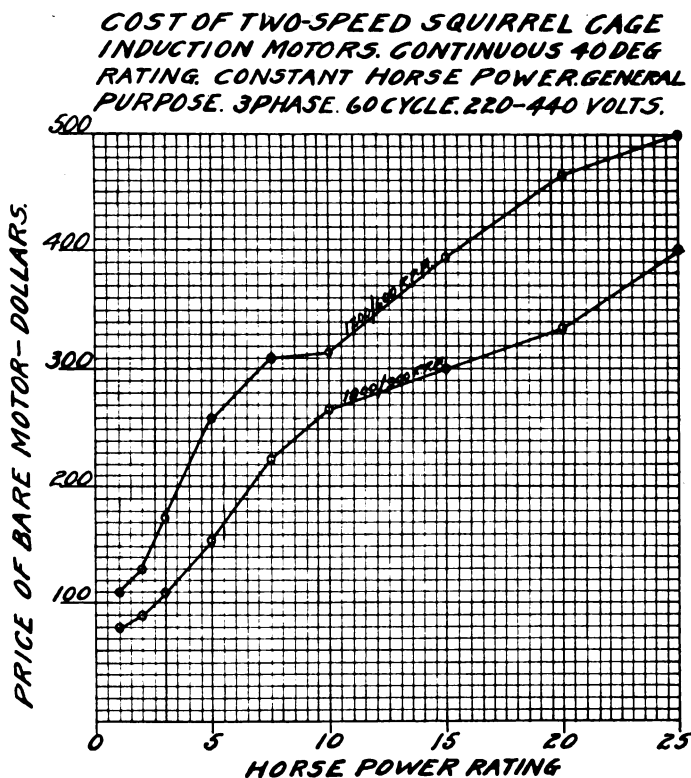


Fig. 20

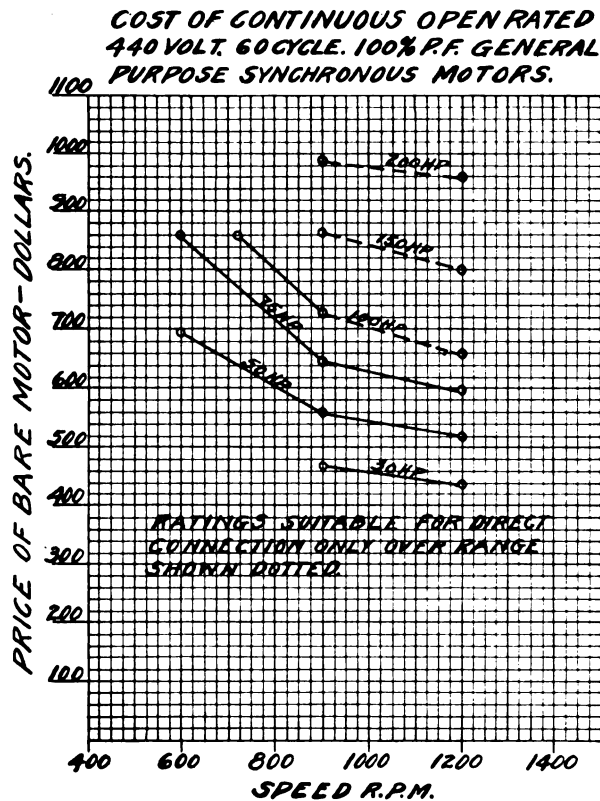


Fig. 21

FIGS. 20 and 21—Cost of motors with characteristics as noted at top of figure.

are interdependent and where the failure of one machine may be of far reaching effect. Very often the losses involved in a motor failure are out of all proportion to the value of the drive equipment. Wherever reliability is of primary importance, a usual condition, the equipment best suited to the work in hand should always be obtained and quality and suitability rather than price should be the ruling consideration.

Users sometimes complain because motors "are not as rugged as they used to be." Granting that cheaper motors are now produced than were formerly available it is also true that rugged, liberal motors are also available to those who are willing to pay the price they would have had to pay for "old time" motors. The fault lies not alone with the manufacturer, but also with the user who places too much emphasis on first cost and too little thought on relative merit.

The purchasing of machines completely equipped with motors is a practice which tends strongly to result in the cheapest possible motor for the job rather than the best suited motor. Competition forces the adoption of the cheapest possible electrical equipment whose lack of merit is often overlooked as of secondary importance, if considered at all. Too seldom is the opinion of the plant electrician either solicited or heeded.

The purchase of complete plants on a lump-sum contract is also likely to result in a minimum installation of motors and control.

Miscellaneous Factors

Some features of motor selection may be influenced by local considerations. For instance, explosion danger may dictate the elimination of collector devices and the submergence of control in oil. Moisture, heat, chemicals or dirt may dictate the use of special insula-

tions or varnishes or total enclosure with special ventilation provisions. Local regulations, such as insurance or mining laws may dictate the maximum voltage to be used. The type of workmen who will use and maintain the equipment must be considered. Many similar special conditions may arise in individual cases.

Last but not least, should be mentioned the desirability of duplicating equipment so far as feasible in any given plant. The use of a minimum number of frames and ratings renders more easy the interchange of motors, facilities, repairs and replacements and greatly reduces the necessary expenditure and increases the value of spare apparatus and parts. The duplication of apparatus is too often neglected to the handicap of both production and maintenance.

Robert C. Lea & Co. Relinquish Sale of Robeson Pig Iron

Robert C. Lea & Company, Stephen Girard Bldg., Philadelphia, which has acted as selling agent for Robeson pig iron, will relinquish that account shortly, when ownership of the Robeson Iron Company will pass into other hands. The firm will continue to sell pig iron on a brokerage basis for other furnaces and will also handle coke, limestone, and allied products. It is one of the oldest firms in the merchant pig iron business, having for several decades been prominent in the eastern pig iron markets. It was first known as J. Tatnall Lea & Company. In 1903 Robert C. Lea withdrew from that firm, taking the Robeson agency with him. J. Tatnall Lea & Company, until a few weeks ago, remained a going business, but confined itself to sales of coal.

The Physical Composition of Steel

A Subject Which Will Demand More Consideration from Steel Manufacturers—Open Hearth and Rolling Mill Practice and Their Influence upon Grain Structure

By JOHN D. GAT*

IN the last few years steel manufacturers have had to recognize a new factor in the usual list of specifications: fibrosity. The term "fibrous," or "reedy," applies to steels which, after fracturing, do not show a smooth surface, but a ragged one, filled with projections and indentations measurable in fractions of an inch. These are caused by the presence of internal planes of weakness along which the metal yields more readily than in the average cross section.

The influence of these planes of weakness is unmistakable, but to give it prominence it has to be intensified by proper recognition of the state in which the steel existed when broken. The general practice dictates a quench and a rather high, 1100-1200-deg. F., draw resulting in sorbite on the verge of pearlite where the metal reaches its maximum toughness, permitting the fracture to travel along the lines of least resistance, which are in this case planes of weakness. Quenched steels, when suddenly broken, do not show the typical ragged fracture, while fully annealed steels give satisfactory results though relatively a somewhat smaller reduction of area and elongation inherent to the pearlitic state.

The desirability of fibrous steel is one of the bitterly disputed subjects. Some American and European engineers advance an opinion that better elongation and reduction of area, together with the presence of the planes of weakness, along which the fracture travels before penetrating the next layer of metal, can be utilized to advantage when the steel is subjected to impact, the realm for which wrought iron is imminently suitable. On the other hand, statements of some large users of steel point, though without any explanation or details to the fact, that most of their forgings, broken in the field, contained some fibre. It is interesting to note that the stresses to which fibrous steel was subjected in the latter case was exactly of the kind for which fibrous steel is recommended.

Physical testing of many hundreds of specimens, of identical analysis and similarly heat treated, half of which contained fibre and the other half free from it, showed that the elastic limit and the ultimate strength of both classes of specimens were identical. Elongation and reduction of area were in favor of fibrous steel. Similar heat treatment produced a greater, on an average between 2 and 3 points Rockwell C, hardness of fibre free steel. Impact values as determined by the Charpy and Izod machines were considerably higher for the fibrous steels, but did not average above 50 per cent over the fibre free metal. The breaking test, as determined by the Humphrey method, again was in favor of fibrous steel.

Chemical data could throw no light on the subject. Analysis for usual constituents never showed any consistent difference in composition of representative samples of both classes. Gas analysis for oxygen and hydrogen by vacuum fusion and for nitrogen by im-

proved evaluation method could not differentiate, after several hundred determinations, between fibrous and fibre free steels.

Microscopical evidence did not show any discernible planes of weakness. Banding could be observed in both types of steel but was of the same intensity and character in both cases. Etching with reagents for phosphorus segregations did not give any indications of it being related to the planes of weakness. Sulphur prints showed a similar pattern on both classes of specimens. Polishing of specimens cut at the fracture did not indicate any definite orientation of non-metallic inclusions and seldom indicated fibre free steel as the dirtier.

Etching of specimens revealed a most interesting phenomenon—fibrous steels invariably had considerably smaller grain. The appearance of carburized specimens was identical with samples of steel generally classified as "abnormal," as it was understood before the establishing of the true cause of abnormality, the presence of iron-carbon-oxygen alloy. Grain size determinations were conducted according to well known McQuaid Ehn test, where the specimens are carburized at 1725 deg. F. until an easily discernible hypereutectoid zone is produced. In this instance most of the readings were made on the core because the steels in question, averaging .27-.32 per cent carbon, had enough pearlite to enable an observer to pass an accurate judgment without the necessity for recurring to a heavy hypereutectoid zone. It was observed that large polygonal grains of approximately the same dimensions were a guarantee of fibre free fracture, while small rounded grains, especially with a tendency for germination, warranted fibre. This was an almost unbroken law.

Physical Tests of No Value

In the light of these determinations all results of physical testing become of little value. It is impossible to find a large grained fibrous steel. Comparing the properties of these two types one works under an assumption that the only point of difference is the presence of the planes of weakness, while actually their influence may be entirely overshadowed by the difference in the size of crystalline units composing the metal. Leaving aside private opinions regarding the merits of different types of steel one has to furnish fibre free steel when the specifications call for it and, therefore, digressing from the more or less academic trend of thought, it is not without interest to follow the line of experiments and reasonings by which the place of origin of fibre was found in practice.

The establishing of the stage in the manufacturing processes which is responsible for the formations of small grains was a matter of much importance, remembering that fibrous fracture is always associated with small grains. Rough subdivision leaves: tapping, teeming, cooling in molds, soaking pit practice, blooming, reheating and final rolling. Tapping

*Metallurgical Engineer.

intimately connected with furnace practice was the last approached and the investigation started with the study of primary crystallization in the molds.

The initial temperature of the metal in the ladle did not give any clues to subsequent behavior of steel. Tapping heats or cold did not give any concordant results. In some occasions large grained metal was produced when the ladles had a comparatively heavy scull while in the next series the same results were obtained when heats were teemed decidedly hot. To see if the difference in grain size could be produced by teeming the same heat at different temperatures half of the molds of a "train" were teemed very hot, then the ladle was allowed to cool until the temperature was at least 150 deg. lower, the nozzle opened with a torch, and the rest of the "train" teemed. No difference could be seen between specimens representing the two halves of the "train." Teeming heats of the same analysis at short intervals covering the temperature range from very hot to quite cold, in molds of the same size and design, did not indicate any definite temperature as conducive to the formation of a given grain size.

The rate of solidification in shop practice is almost a direct function of the size, shape and design of molds and their temperature. The temperature of the ladle, if to judge from the results of previous experiments, has so little to do with the size of crystalline dimensions that it could be assumed to be a constant in a series conducted for the purpose of controlling the rate of solidification. It was possible to vary the speed of cooling within comparatively wide limits and to reproduce almost all conditions in the molds which may be encountered in regular practice. The existence of a definite cooling ratio, which invariably could be associated with small grained steel, could be considered as a strong support to the theory that the origin of small grained structure is not in the furnace.

In order to ascertain this more definitely, some heats were teemed in trains of molds of greatly different dimensions. The speed of cooling is roughly inversely proportional to the square of the cross section of a mold. While a 7 x 7-in. ingot solidifies inside of five minutes the central part of a 20 x 20-in. ingot remains liquid, if left in a mold, after 30 minutes, following teeming. Some of the trains consisted of 32 x 32-in., 22 x 22-in., 15 x 17-in., 13 x 13-in. and 7 x 7-in. molds. It was thought inadvisable to use larger or smaller cross sections because the use of these sizes is an exception rather than a rule in the standard practice of the plants in which the experiments were conducted. Placed in the furnace pit at approximately the same temperature, they had enough time before teeming to cool to about the same temperature so that it was possible to assume that the metal was introduced in uniformly heated molds.

Effects of Rate of Cooling

The range of cooling ratio was sufficiently wide to make the influence of it, at least at the opposite ends of the range, easily discernible under a microscope or by examination of macrostructure. To prevent the distortion of the results obtained by the difference in the rates of cooling it was necessary to pay special attention to rolling practice so as to keep all its variables constant, which was not difficult with the exception of blooming mill practice where reduction to the same size of billets, 4 x 4-in., necessarily involved more work on larger cross sections. All finishing

temperatures were kept well above the critical to insure the freedom from the introduction of crystalline transformations caused by a slight cold working. Specimens were taken from every ingot and at every stage of conversion. While fracture of ingots, as removed from the molds, showed the difference in cooling very pronouncedly, carburization did not point to any changes in crystalline dimensions. In the light of these observations it was difficult to see any relation between the size of the grains and dimensions of the molds as they influenced different rates of cooling of the metal.

Types of Ingot Molds Employed

To broaden the field of observation the influence of the temperature interval, between the molten metal and the mold, was investigated by heating the same type and size of molds to predetermined temperatures and studying the effects of the retarded cooling so produced. This was followed by attempts to change not only the rate of cooling, the equations of which are the same for identical profile of molds varying only according to the thermal gradient existing between the metal and the mold, but the equations of cooling themselves, by selection of differently designed molds. Gatham molds (big end up), Bradford (with very fast cooling at the bottom), straight walled molds used for open steels, molds, square hexagonal, having 18 angles (fluted), with or without hot tops, were tried, but the results were always the same, grain size and fibrosity of a heat did not change.

Many thousand examinations of heat treated and broken bars showed that most pronounced irregularities of the fracture occur usually near the center of the bars. This gave a further strength to the theory of primary crystallization of ingots resulting in rejection towards the center, of some of the constituents present in commercial steels. These, being definitely oriented, could create conditions conducive to irregular displacement of the plane of fracture.

A considerable number of experiments was conducted in order to reach a conclusion, though only two of them are described in the following discussion as more representative. Many 20 x 20-in. ingots were split longitudinally and the halves were rolled as usual after proper preheating in soaking pits. The orientation of different components and inclusions in steel produced by primary crystallization may be, for practical purposes, considered as constant until the metal is remelted or very severely deformed. If a pronounced difference in the constitution of the outer layers and the center of an ingot is responsible for fibrous fracture and small grain associated with it, rolling of a split ingot will produce a bar in which the irregular fracture will be observed, not in or around the center, but at one side. Repeated rolling of split ingots did not, in a single instance, change the grain size across the bars or the location of the irregular fracture which always was present at the center.

The study of distribution of fracture irregularities along the axis of ingots gave some valuable information regarding their increase towards the bottom. This is in accord with our present understanding of the mechanism of ingot solidification. If planes of weakness causing abnormal fracture are due to the presence of films of a different composition than the mass of the metal there is less chance to effect them in the upper part of an ingot. Even if the steel when leaving the furnace has all its non-metallic impuri-

ties in the shape of more or less perfect spheres ladle additions and oxidation of the surface of the stream of steel, followed by subsequent reduction, are capable of production of a considerable amount of non-metallic films. The surface tension of more fusible compounds, chiefly sulphides and slag, can reduce films into spheres with comparative ease, provided the surrounding liquid has a sufficiently low viscosity.

Alumina and similar films are not affected. Viscosity in case of molten steel is practically a direct function of the temperature which is governed in the molds by their design and the time elapsed since teeming. In the lower parts of ingots, solidifying faster than the tops, films of non-metallic inclusions are fixed in the metal as such, while in the higher layers some of them have time for at least partial coagulation.

Rolling deforms plastic non-metallics in about the same way as the ingot itself. Therefore a sphere in an ingot after rolling it into a bar, will be transformed into a cylinder of a very small diameter if the reduction is large. A film after the same deformation will remain as before a two dimensional body, but of many times larger size. A load applied perpendicularly to both of them will produce, in the first instance, a fracture the direction of which will digress from the original only an almost microscopical distance, but on meeting a long film it will follow the direction of least resistance.

Fibre Accompanies Small Grains

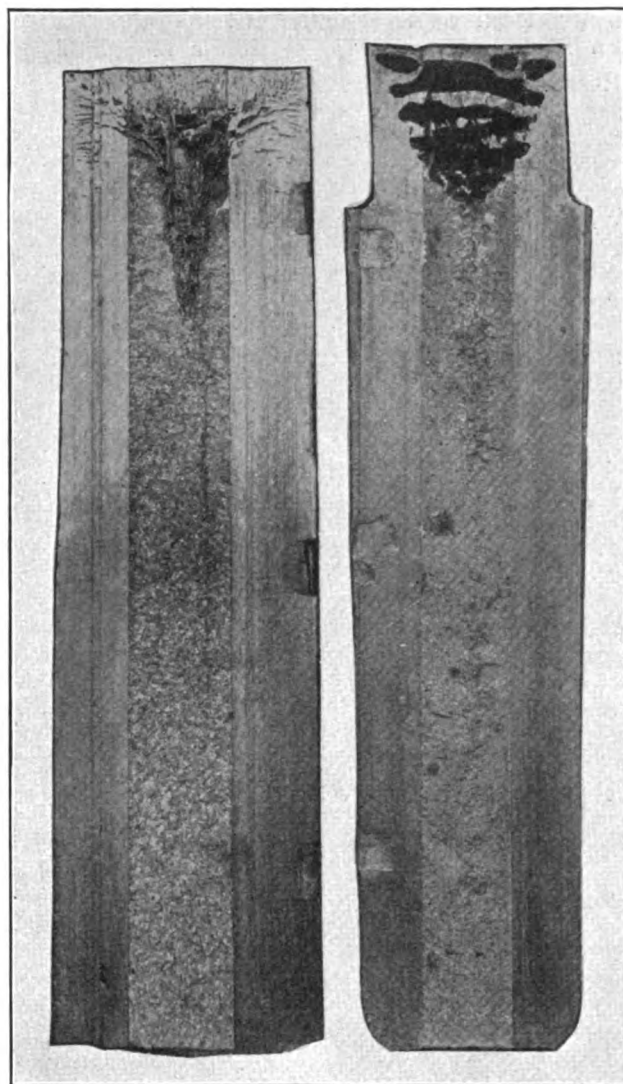
The remarks regarding the distribution of fibre in steel do not have any special intrinsic value, being in close accord with the solidification phenomena frequently discussed in print, but followed by properly devised experiments they bring to light a most interesting observation. This is that fibrous steel is always associated with small grained structures, but the latter does not necessarily imply a fibrous steel.

It is, as a general rule, impossible to find in the same heat areas with different grain size. This statement was supported by examination of several hundred heats. On the other hand, quite often one part of an ingot has fibre while adjoining it is fibre free. It was interesting to find whether or not very small variations, which could be observed in the grain size of some heats, can be connected with the presence of fibre.

Six heats were selected for the experiment before they were charged in open hearths. All information bearing on the practice followed and the behavior of the metal in the furnaces were carefully recorded. After teeming, the fifteenth ingot of each heat (it usually takes 33 ingots to teem a heat) was set aside. The rest were rolled as usual into bars which were checked for their fibrosity according to the accepted practice. Some of the heats were fibrous, some were not. Three ingots representing heats with maximum, minimum and average fibrosity were taken out of the six set aside for this purpose. Three slices were cut from each of them at the butt, in the middle and 2 in. under the hot top. The slices, measuring 20 x 20 x 1 in., were divided on a shaper into cubes 1 in. on the side. After proper identification they were carburized as usual.

Examination of these slices showed a crystalline structure of the ingots in question and supported the views derived before from the study of grain size variations in different sections of ingots. Normality

remained without the slightest change from the bottom to the top. Grain dimensions varied almost imperceptibly, with a slight diminishing tendency at the top, but not enough to place the steel in the next class according to grain size. The ingots with medium fibre content was the most instructive because it was possible to compare in it fibre free top, and fibrous bottom, with the grain size of corresponding sections.



Left—Split straight walled mold ingots. Through the shrinkage cavity is well pronounced, it still can be accentuated by incorrect pouring temperature. Right—Ingots made in modern tapered molds. Left teemed too cold, center too hot, right perfect ingot.

The results were distinctly in favor of the conclusion that grain size, often misunderstood as normality, is totally independent of the character of the fracture. Taken in connection with a great many fracture examinations compared with corresponding crystalline structure these observations definitely indicate that, while fibre phenomena are subjected to the effects of solidification of ingots, grain size of steel is entirely independent from conditions governing the crystallization of the metal in the molds.

Previously the presence of non-metallic films, acting as planes of weakness, was only assumed because the usual microscopic examination did not show any of them. The existence of these films could be considered as a key for the whole problem, thereby elimi-

nating from consideration the influence of mechanical transformations and concentrating all attention on the processes of steel making proper.

Step down test accidentally applied to some fibrous bars was the first approach to this puzzling dilemma. All experimental work pointed to the presence of films, while one of the most accurate methods for their identification, microscopic analysis, repeatedly gave negative results. A step down test consists in turning from a piece, under investigations, a specimen resembling in cross section a step ladder and polishing the surface so formed. The difference in light reflection between the metal and stringers of hard (not sulphides) inclusions permits their easy identification and allow an accurate estimate of their distribution and size. Applied to fibrous bars the test revealed many long stringers distributed without any definite orientation, parallelism with the direction of rolling excepted, in the body of the metal. Their length, measurable sometimes in inches, could account for the deepest indentations on fractured surface, but was not sufficient to form a continuous plane of weakness along the whole bar. When such a bar is broken the fracture, meeting these stringers, follows them to the end so that a section for microexamination taken at the end of an indentation passes through sound metal while the next stringer may be several inches distant. The usual size of microsections misses them as a general rule, and only by polishing sections with area of several square inches was it possible to attribute definitely fibrous fracture to the presence of non-metallic films.

In the light of these observations the responsibility for fibrous fracture was definitely shifted to the conditions inducing the formation of the films of non-metallics. Mechanical treatment cannot either create or destroy them. Solidification phenomena accompanying freezing of the metal in the molds can only orient definitely non-metallics already present. Teeming, though connected through oxidation of the stream with the formation of a certain amount of oxides, does not introduce a sufficient amount of them to produce heavy films necessary for fibrous breakage. Tapping cannot be considered separately from furnace practice, while the latter is almost entirely responsible for the state of oxidation of the molten bath finally resulting in the formation of the included oxides.

Approached from this angle the problem of fibre elimination yielded to the efforts of furnace men comparatively easily, and by proper modifications in the standard furnace practice of at least 80 per cent of heats were made entirely fibre free, 15 per cent had trace of it, and 5 per cent were fibrous, while before the change 80 per cent were fibrous and 20 per cent fibre free.

Condition of Coal Supply

It is now clearly seen that the majority of industrial concerns have been quietly but persistently stocking coal and it is conceded that there are ample supplies available for industrial purposes as the bituminous strike threat approaches a reality.

The National Association of Purchasing Agent's coal survey shows a total of 65,735,000 tons on hand as of March 1st, an average day's supply for all industries of 43 days.

In February, the shorter month accounted for a slight decline in the volume of production, the total

bituminous and anthracite tonnage amounting to 58,696,000. Of this total 52,905,000 tons were bituminous and 5,791,000 tons composed the anthracite.

The production of by-product coke registered a further decline in February—76 active plants produced at about 88% of their capacity a total of 3,435,000 tons. The bee-hive output likewise declined with a total estimated at 7,540,000 tons. The daily rate, however, was more than 1,000 tons in excess of that of January. The total coke output for the month was 4,189,000 tons and a total of 6,240,000 tons of coal was used for the manufacture of coke during February.

The interest of coal buyers has been centered recently on the resolutions passed by the United Mine Workers permitting operators outside of the Central Competitive field, to continue operations after April 1st under the old Jacksonville wage scale. Many of the operators outside of the Central Competitive District have indicated that they will continue to work their mines on this basis. This arrangement is not subject to a time limit and can terminate at the will of either operators or the Union. The fact that these union mines will continue their production after April 1st gives further assurance that ample coal will be available for a normal rate of industrial activity.

The general press has commented widely on the possibility of several prominent Pennsylvania coal Companies changing from union to non-union operations if a settlement of the United Mine Workers is not reached by April 1st.

Twenty-seven Awards to G. E. Employees

Twenty seven employees of the General Electric Company on March 4 were awarded Charles A. Coffin Foundation certificates of merit for their outstanding services toward the increase of the company's efficiency or progress in the electrical art during 1926. With each certificate went four shares of General Electric common stock. One-third of the 27 awards were to workmen, two to foremen, eight to engineers, five to commercial men, and three to administrative employees.

The Charles A. Coffin Foundation, which makes the awards, was founded by the General Electric Company in 1922 in recognition of the services to the electrical industry of the late Charles A. Coffin, first president of the company, who died last summer. The awards of the Foundation include, in addition to those to General Electric employees, yearly prizes in the Electric Railway and Power fields, and a number of annual fellowships in American universities.

The employees' awards for 1926 include: Guy S. Purvis, construction engineer at the Chicago office, in the employ of the company 21 years, who did remarkable work in helping to place in operation a new type of reversing mill control in a steel mill. The previous time record required for a change of this kind, 19 days, was reduced to 6 days. Mr. Purvis made all necessary adjustments on the control, so that on the first day of production with electricity, the mill exceeded its own previous record.

Fred P. Wilson, Jr., engineer in the manufacturing methods department, Schenectady, in the employ of the company a year and a half, who developed methods of utilizing illuminating gas in metal-cutting operations, which resulted in remarkable reductions in cost.

A New Blast Furnace Process*

After a Survey of Present Practice in Melting Iron Ores, the
Author Suggests the Use of Water Gas as a
Fuel Instead of Coal or Coke

By P. W. UHLMANN

THE well-known method of reducing the iron ore to metal in the blast furnace is a simple one and its great advantage lies in this fact. Nevertheless, the process possesses an important disadvantage which lies in the fact that the consumption of fuel is uneconomical. Furthermore, due to the fact that impurities are present in the coke, that is sulphur and silica, a correspondingly impure iron and considerable quantities of slag are formed.

Attempts have been made, and these have been partially successful, to use the electric current in the blast furnace as a source of heat, but this practice entails an important disadvantage in that it is connected with a large consumption of electrode carbon. It has been determined that the reduction of the iron oxide is principally accomplished not by the solid carbon, but by the hydrocarbons and carbon monoxide. The idea has therefore suggested itself that, if the introduction of the impurities contained in the coke is to be avoided, a reducing gas should be allowed to act on the hot metallic oxide and thus the reduction will be accomplished by means of a gas, while the additional heat required in the blast is simultaneously supplied by means of the same gas. Due to the fact that the author lacks information at this time—there being no such information available in the literature—he has not been able to determine what experiments have already been made on this same subject. He has therefore limited himself to a study of the new process from the theoretical, thermal standpoint, using therein whatever incomplete information he has been able to gather together from the literature. The following conditions are fundamental in this study.

The molecular heat of formation of ferrous oxide (FeO) at a temperature of 1,000 deg. C. is 72 calories or 91,000 per ton; that of Fe_2O_3 at the same temperature 160 calories or 123,000 per ton; and that of Fe_3O_4 232 calories at the same temperature or 112,400 calories per ton. The heat of melting of iron is 33 calories, its specific heat is 0.2 and that of ferrous oxide is approximately the same. The specific heat of steam is approximately 0.5 (0.4805), that of carbon monoxide 0.2426, that of nitrogen 0.2438 and that of carbon dioxide 0.2160. The latent heat of evaporation of steam is 636 calories. One kilowatt of electricity yields 3.65 cu. ft., equals 0.103 cu. meters of oxygen equals 0.206 cu. meter of hydrogen. The generation of 1 cu. meter of oxygen requires approximately 9.7 kwh., while that of 1 cu. meter of hydrogen requires 4.85 kwh. One kilogram of hydrogen yields 28,000 calories, while 1 cu. meter of hydrogen gives 2,520 calories or 2500 calories in round numbers. One cu. meter of hydrogen requires half a cu. meter of oxygen for combustion or 2.5 cu. meters of air. The combustion 1 kg. of carbon monoxide results in the production of 2,403 calories of heat, while 1 cu. meter

of the carbon monoxide yields 3,004 calories or 3,000 in round numbers and requires for combustion 1 cu. meter of oxygen or 5 cu. meters of air. One cu. meter of water gas yields 2,700 calories, requires 0.75 cu. meter of oxygen for combustion or 3.75 cu. meters of air.

All the aforementioned figures are used in round numbers in order to simplify the calculations. The first calculations are carried out on the basis of the gas required for the complete reduction of 1,000 kg. of the various iron oxides, thus ferrous oxide (FeO), Fe_2O_3 and Fe_3O_4 . Thus in the first case there will be required for the reduction of 1,000 kg of ferrous oxide, 30 kg. of 335 cu. meters of hydrogen, generating 837,000 calories of heat, 400 kg. of carbon monoxide or 330 cu. meters, generating 990,000 calories of heat and 332 cu. meters of water gas, giving 896,000 calories of heat.

Fuel Consumptions

For the reduction of 1,000 kg of ferric oxide (Fe_2O_3), there are required 430 cu. meters of hydrogen, generating 1,075,000 calories of heat, 420 cu. meters of carbon monoxide, generating 1,260,000 calories of heat and 425 cu. meters of water gas, generating 1,137,000 calories of heat.

For the reduction of 1,000 kg. of iron sesquioxide (Fe_3O_4), there are required 384 cu. meters of hydrogen, generating 960,000 calories of heat, 375 cu. meters of carbon monoxide generating 1,125,000 calories of heat and 379 cu. meters of water gas, generating 1,023,300 calories of heat.

It therefore follows that the consumption of heat, required for the reduction of 1 ton of the iron ore on the assumption that 700 kg. of molten iron will be produced on the average from that quantity of mineral, will be as follows, when hydrogen is employed as the heating agent.

	FeO Calories	Fe_2O_3 Calories
For reduction	95,000	125,000
Heating the ore to 2,000 deg. C.	400,000	400,000
Melting 700 kg of iron	33,000	33,000
Evaporating the water present	171,720 (270 kg.)	221,512 (342 kg.)
Superheating to 2,000 deg. C.	270,000	324,000
Total heat	969,720	1,121,512

The total heat in the case of iron sesquioxide (Fe_3O_4) is approximately 1,046,000 calories.

The consumption of heat when carbon monoxide is employed is as follows, all the conditions being maintained constant.

	FeO Calories	Fe_3O_4 Calories
For reduction	95,000	125,000
Heating to 2,000 deg. C.	400,000	400,000
Melting of approximately 700 kg. of iron	33,000	33,000
Heating carbon dioxide to 2,000 deg. C.	150,000 (625 kg.) or 350 cu. meters	173,000 (825 kg.) or 450 cu. meters
Total heat	678,000	731,000

*Translated from Chemiker Zeitung, 1927, by Ismar Ginsberg, Consulting Engineer, New York.

The approximate heat required for iron sesquioxide (Fe_2O_3) is 704,500 calories.

The heat consumption and production when hydrogen is employed is as follows:

	FeO Calories	Fe_2O_3 Calories	Fe_3O_4 Calories
Heat required, approximately	970,000	1,122,000	1,046,000
Heat produced, approximately	837,000	1,075,000	960,000
Heat supply necessary	133,000	47,000	86,000

When carbon monoxide is used, the following figures are obtained:

	FeO Calories	Fe_2O_3 Calories	Fe_3O_4 Calories
Heat produced, approximately	990,000	1,260,000	1,125,000
Heat required, approximately	678,000	731,000	705,000
Heat Excess	312,000	529,000	420,000

When water gas is employed as a fuel, the heat required and produced is shown in the following tabulation:

	FeO Calories	Fe_2O_3 Calories	Fe_3O_4 Calories
Heat produced	913,000	1,167,500	1,042,500
Heat required	824,000	926,500	875,500
Heat excess	89,500	241,000	167,000

On the assumption that all the reactions were carried out with 100 per cent efficiency, it is first concluded from the figures given in the above tabulations that the use of hydrogen appears unsuitable, for in this case the heat of reaction is considerably less than the heat required in the blast furnace.

Efficiency of Processes

However, it is still necessary to carry out experiments to determine the efficiency of the individual processes. On the other hand, it has been found by preliminary experimentation that the efficiency of the process in which hydrogen is employed for reducing purposes is greater than that obtained when carbon monoxide is used. The conclusion is therefore reached that the method, that should be used, is the one in which water gas, enriched with hydrogen, is the reducing agent. The manufacture of such a gas indicates that it is necessary to carry out an electrolytic decomposition of water, which results in the production of both hydrogen and oxygen. The oxygen is separately collected and thus a supply of hydrogen gas is obtained. The water gas generator is operated by blowing through the bed of fuel a mixture of steam and oxygen which is obtained from the decomposition of water. This process possesses the advantage that it can be operated in a so-called continuous fashion, for the hot blast period of the water gas process can be omitted. The gas which is made in the water gas generator contains approximately 70 per cent of carbon monoxide and 30 per cent of hydrogen. This gas is then mixed with an equal amount of hydrogen and the mixed gas will then contain approximately 35 per cent of carbon monoxide and approximately 65 per cent of hydrogen. The heating value of this gas is approximately 2,675 calories per cu. meter.

On the assumption that a 100 per cent pure ore is smelted in the blast furnace, that is ore that does not contain any foreign substances, then such a gas, would keep the blast furnace in constant operation once it had been hot blown. For the quantity of superheated steam produced and hot carbon dioxide

gas could be used to preheat the cold mineral up to a temperature of 1,000 deg. C. at any rate before it entered the smelting zone. It is however evident that such ideal ores will be met with only in the rarest cases and hence the process does not take place with 100 per cent efficiency. The really practical working of the process entails the use of an additional quantity, from 30 to 40 per cent, of the gas and a part of the gas is consumed in the blast furnace with the formation of flame by means of the blast of hot air.

If now a comparison is made between the consumption of electricity which is entailed by the use of pure hydrogen gas, which has been manufactured by the electrolytic process, and the consumption of electricity in the electro-iron process, then the following comparative figures are obtained.

One ton of ore (FeO) requires 330 cu. meters of hydrogen for reduction, or 1 ton of iron requires approximately 500 cu. meters of hydrogen which is equivalent to 4.85 kwh. of electricity (5 kwh. in round numbers) per cu. meter of the gas, which makes a total of 2,425 kwh. (2500 in round numbers). These figures are based on practical, large scale operation and are guaranteed to be accurate.

In contradistinction we have the results that have been obtained in the operation of electric blast furnaces, which indicate that for 1 ton of iron there are required at Hardanger 4,000 kwh., at Hagsfor 2,219 to 2,383 kwh., at Trollhaetten 2,225 to 2,007 kwh., at Shasta County, Cal., 2,200 kwh. and at Darfo in Valcomonica 2,100 kwh. The author has not included certain other systems of operation in which the consumption of electric current is considerably greater than the aforementioned figures.

Indirect Process Economical

A study of these figures will reveal the fact that the use of the indirect process of operating the blast furnace with a consumption of 2,500 kwh. per ton of iron produced is economical and can stand comparison on a competitive basis with large scale operation of the direct electrical process. This holds good particularly because of the fact that there is no consumption of electrodes or of fuel, that is carbon for reducing purposes in the blast furnace, in the new process. Furthermore the quality and purity of the iron produced are much greater than in the direct, electrical process, this being due to the avoidance of contamination of the iron with the impurities that exist in the fuel. Finally it must also be mentioned that the productivity of the blast furnace is increased.

The minimum consumption of electrode carbon in the electric iron process is about 2 to 3 kg. per ton. The electrodes that are used in the process of decomposing water to obtain hydrogen gas are practically permanently durable. The author has studied the numerical results which have been described above and has come to the conclusion that the new process, which has given very good results when carried out on a small plant scale operation, can be carried out on a large scale in an economically advantageous manner. This holds good particularly in the case where combustible is hard to obtain, and where on the other hand there is a source of electricity near at hand. The process is accordingly very interesting to those countries or plants which are located in the proximity of water falls, and where coke or anthracite is hard to get. It is also of particularly great interest to those

works which are located near sources of supply of natural gas, lignite or liquid fuel, which are very cheap fuels.

It is obvious that it is satisfactory to obtain the hydrogen and carbon monoxide gases from any other source in addition to the one that has been described above. Thus it is possible to obtain them by the decomposition of hydrocarbons or liquid carbohydrates, and vapors, mists or dusts of crude petroleum, tar oils, tar, alcohols, etc. It is just as self-evident that the formation of flame can be effected with oxygen in place of air, and this results in the production of higher temperatures and waste gases free from nitrogen are accordingly obtained.

The high point of fusion of an iron which is poor in carbon on the one hand and the necessity of a certain proportion of carbon for the purpose of the production of steel on the other hand makes it naturally necessary for the addition of some carbonaceous substance to the blast furnace process. Such substances, as wood charcoal, anthracite coal, coke are added. It may also be possible to blow in tars into the heating chamber and to effect the partial carbonization of this tar.

Construction of Apparatus

As far as the design and the construction of the apparatus are concerned, it may only be mentioned that the hearth is made in larger dimensions than usual and that the placing of the nozzles through which the required gases are introduced into the blast furnace is tangential to the inner feed cone in the heating chamber so that a whirling flame motion is obtained. The ease with which the condition of the hearth can be observed, and this pertains to the melting chamber as well and that the fact that the apparatus is being operated with gases or liquids make it possible to control a blast furnace, which is constructed in this fashion much more accurately than under ordinary conditions and hence the operation is particularly characterized in possessing a high degree of elasticity. This is of particular importance in the manufacture of ferro-manganese, ferro-chrome and other similar products. The construction of large water-decomposing apparatus with the necessary productive capacity has also been studied by the writer and he can state that no serious technical difficulties are involved either in the design or the operation of such an apparatus. The danger of explosion, which appears at first glance to be of particularly great importance in the operation of such a blast furnace, particularly when the furnace is blown, can be easily avoided. The manner of doing so is well known to every practical man.

The process, which has been described above, is naturally limited in its application to oxidized ores or such ores, which are converted into the oxide form before they enter the reducing zone of the blast furnace, this conversion being effected by the high temperatures that exist in the furnace. No attention was paid in the foregoing calculations to the consumption of heat due to the impurities in the ores and to the slag-forming ingredients added to the blast furnace.

Relation of Fusibility of Coal Ash to the Formation of Clinkers

A co-operative investigation for the purpose of determining some property of coal ash susceptible to reasonably accurate measurement in the laboratory which would serve as an index to its clinkering characteristics in boiler furnaces has been undertaken by Carnegie Institute of Technology and the Bureau of Mines, Department of Commerce. The importance of a solution of this problem to consumers and producers of coal is obvious. The investigation was undertaken at the request of the Committee on Coal and Coke of the American Society for Testing Materials.

Seven coals, having ash-fusion temperatures ranking from 2,070 to 2,930 deg. F., were selected for comparative burning tests in a specially designed hand-fired furnace with a circular grate 20 inches in diameter and water-cooled iron walls. The furnace was so arranged that the air supply could be accurately controlled and measured; likewise temperatures could be observed at various points in the fuel-bed. Tests were made at 20, 30, and 60 lbs. of coal burned per square foot of grate-area per hour, and in certain tests the fuel-bed was occasionally stirred. Observations on clinked formation were made during the tests, and after completion the percentage of ash fused into clinker was determined. These observations and determinations were then compared with the fusibility of the average ash of the coal fired and also with the fusibility of the intrinsic ash of the coal. The inherent intrinsic ash is that which is intimately mixed with the coal substance and which cannot be removed by coal-washing processes.

Although coals are being tested during the present year and research is required on the relation which exists between the burning of the coals in the small furnace and the various methods used in practice, the following tentative conclusions may be made from the work done during the past year.

The average quantity of clinker formation relative to the total ash in the coal and also the size of the clinker pieces seems to have a fairly definite relation to the softening temperature of the coal ash, as determined by the standard gas-furnace method.

This relation is better expressed by using the softening temperature than it is by that of the initial or fused temperatures.

No better relation can be obtained from the softening temperatures of the ash of the float-and-sink portions of the coal separated by fine grinding and using a liquid of 1.35 specific gravity.

The clinker formation does not increase materially until the softening temperature of the coal ash is below 2,600 deg. F.

The seven coals selected for test in this investigation included bituminous coals from Ohio and Illinois and semi-bituminous coals from Pennsylvania and Maryland.

The results of this investigation are outlined in Bulletin 29, Mining and Metallurgical Investigations, by W. A. Selvig and P. Nicholls, of the Bureau of Mines, and W. L. Gardner and W. E. Muntz, of Carnegie Institute of Technology. Copies of the bulletin may be obtained from Carnegie Institute of Technology, Pittsburgh, Pa., at a price of 50 cents.

Seamless Steel Tubing; A Bibliography

Practically All Phases of Tube Manufacture Are Covered—Pilger
and Mannesmann Processes Receive Special Attention
—American and Foreign Practice Reviewed

Compiled by VICTOR S. POLANSKY*

PART III

Rohrleitung aus Mannesmannröhren. 1891. (In Dingler's Polytechnisches Journal, v. 282, p. 71-72.)

Comments on Siemens' article published in "Dinglers polytechnische journal," v. 280, p. 301.

Rolling Mills for Billets and Tubes. 1910. (In Mechanical Engineer, v. 25, p. 354.)

Illustrated description of rolling mills, comprising rolls having planetary movement with circular operative surfaces, the invention of Mannesmannröhren-Werke.

Rolling Seamless Pipe from Hollow Ingots. 1890. (In Iron Age, v. 46, p. 632-633, plate following p. 636.)

Describes the Kellogg machine which consists of a series of rolls, alternately horizontal and vertical, supported in housings which are secured to the bed plate of the machine. Positive motion is secured by properly proportioned gear wheels.

Rolling Seamless Tubes. 1907. (In Iron Age, v. 80, p. 553-555.)

Discusses the phenomenon of the central rupture in cross rolling.

Ross, E. F. Making Seamless Steel Tubes by Improved Processes. 1925. (In Iron Trade Review, v. 77, p. 1079-1083, 1091.)

Discusses most recent development of a process which features the use of square billets, also known as push-bench process.

Rössler. Rohrenfabrikation. 1903. (In Zeitschrift des Vereines Deutscher Ingenieure, v. 47, pt. 1, p. 283-289.)

Brief treatment of the manufacture of tubes of iron, steel, copper and of their alloys. Includes seamless tubes.

Sargent, Edward. Threading Seamless Tubes. 1934. (In American Machinist, v. 27, pt. 1, p. 325-326.)

Describes briefly method employed by author in threading open-hearth steel seamless tubes.

Schulz, E. H., and Fiedler, R. Untersuchung eines gebrochenen nahtlos gezogenen Rohres. 1920. (In Stahl und Eisen, v. 40, pt. 1, p. 21-24.)

Seamless tube which had split longitudinally in service was tested chemically and by tensile specimens, but the cause could not be found.

Seamless Steel Tube Plant Being Built. 1920. (In Blast Furnace and Steel Plant, v. 8, p. 88.)

Brief description of the plant being constructed by the Detroit Seamless Steel Tube Co., which will produce twenty-five tons of seamless steel tubing per month.

[Seamless Steel Tubing.] 1917. (In Machinery's Encyclopedia, v. 2, p. 301; v. 6, p. 333-339.)

Gives results of test on strength of seamless tubes, v. 2, p. 301, and discusses the development of the various processes, v. 6, p. 333-339.

Seamless Tubes Made from Solid Blanks. 1887. (In American Machinist, v. 10, no. 42, p. 1-2.)

The same, condensed. 1887. (In Engineer, v. 64, p. 396.)

*Carnegie Library of Pittsburgh.

The same, condensed. 1887. (In Railroad Gazette, v. 19, p. 664-665.)

Illustrated description of the Mannesmann process of making seamless tubes.

Seamless Tube Mill Employs Forging Rather than Rolling Principle. 1926. (In Iron and Coal Trade Review, v. 79, p. 773-776.)

Description of the new seamless tube mill of the Pittsburgh Steel Products Co. at Allenport.

Seamless Tubes by Mechanical Mill. 1926. (In Iron Age, v. 117, p. 681-685.)

Describes an automatic Pilger mill, claimed to be the first one in the United States, employed by the Delaware Seamless Tube Co.

Seel, Fritz. Mannesmann Seamless Steel Joint Tubes. 1912. (In Iron Age, v. 90, pt. 1, p. 126-127.)

Synopsis of a paper read before the Track Superintendents' Society of the Railroads in the Cossel district and published in "Wochenschrift fuer Deutsche Bahnmeister," dealing with the development and application of the Mannesmann process.

Shaner, E. L. Build New Tube Mill in Detroit. 1920. (In Iron Trade Review, v. 67, p. 1805-1809, 1820.)

Illustrated description of a new seamless tube mill erected for the Detroit Seamless Steel Tube Co.

Sharp, John. Some Considerations Regarding Cast Iron and Steel Pipes. 1914. Longmans.

Treats of relative corrosion of cast iron, mild steel and Mannesmann steel tubes, p. 100-106.

Shelby Steel Tube Company Wins Its Patent Suit. 1907. (In Iron Age, v. 79, p. 1042-1044.)

Gives result of suit between Shelby Steel Tube Co. and the Delaware Seamless Tube Co., and discusses the history of the art of Mannesmann and Stiefel processes of seamless tube rolling.

Siemens, Friedrich. Mannesmann'sche Verfahren, nahtlose Rohre aus dem vollem Stücke ohne Dorn zu walzen. 1888. (In Journal für Gasbeleuchtung und Wasserversorgung, v. 31, p. 663-668.)

The same. 1888. (In Dingler's Polytechnisches Journal, v. 269, p. 454-466, 503-511, incomplete.)

The same, abstract translation. 1891. (In Minutes of Proceedings of the Institution of Civil Engineers, v. 107, p. 528.)

Paper read before Saechsichen Ingenieur- und Architektenvereines," deals with the manufacture of seamless tubes from solid bars and appliances used.

Siemens, Fredrich. Rolling Seamless Tubes. 1888. (In Engineering, v. 46, p. 291-292.)

The same. 1888. (In American Engineer, v. 16, p. 128-129.)

The same. 1888. (In Scientific American Supplement, v. 26, p. 10,720-10,721.)

The same, abstract. 1888. (In Journal of the Iron and Steel Institute, v. 33, p. 286-288.)

The same, abstract. 1891. (In Locomotive, n. s. v. 12, p. 1-4.)

The same, abstract. 1888. (In Report of the British Association for the Advancement of Science, v. 58, p. 804-805.)

The same, abstract. 1890. (In Scientific American, v. 77, n. s. v. 63, p. 198.)

The same, abstract translation. 1889. (In La Nature, v. 32, p. 99-100.)

The same, abstract translation. 1888. (In Oesterreichische Zeitschrift für Berg- und Hüttenwesen, v. 36, p. 417.)

The same, abstract translation. 1888. (In Stahl und Eisen, v. 8, pt. 2, p. 441-442.)

The same, abstract translation. 1888. (In Technische Rundschau, v. 2, p. 219-220.)

Describes the Mannesmann process of rolling seamless tubes from solid bars or ingots.

Siemens, Friedrich. Verwerthung der Mannesmann'sche Walzröhren zu Pumpzwecken. 1891. (In Verhandlung des Vereins zur Beförderung des Gewerbfleißes, v. 70, Kleine mittheilungen, p. 172-173.)

Includes also a reprint of an article from the "Civilingenieur," v. 34, no. 3, on "Das Mannesmann'sche Verfahren, nahtlose Röhren aus dem vollen Stücke ohne Dorn zu Walzen," by Friedrich Siemens.

The same, abstract. 1891. (In Dingler's Polytechnisches Journal, v. 280, p. 301.)

The same, abstract. 1891. (In Journal für Gasbeleuchtung und Wasserversorgung, v. 34, p. 379.)

The same, abstract. 1891. (In Stahl und Eisen, v. 11, pt. 1, p. 516.)

Sisco, F. T., and Boulton, H. W. Welding Steel Tubing and Sheet with Chromium-Molybdenum Welding Wire. 1925. (In American Society for Steel Treating, v. 8, p. 589-619.)

Discussion. p. 619-620, 665-668.

In welding chromium-molybdenum steel seamless tubing, chromium-molybdenum welding wire produces weld which has more desirable and uniform structure than low carbon welding wire; in welding chromium-molybdenum steel tubing to plain carbon steel tubing chromium-molybdenum steel welding wire is not greatly superior and may even be inferior to low carbon wire.

Slocum, S. E. Collapse of Tubes under External Pressure. 1909. (In Engineering, v. 87, p. 35-37.)

Discussion of Cormon's and Stewart's experiments. Suggests that discrepancy between theoretical formula and experimental results is probably due to imperfections in geometrical forms. Proposes a correction factor C in the formula:

$$p = C \frac{2E}{1 - m^2} \left\{ \frac{t}{D} \right\}^3.$$

The value of C for solid drawn weldless steel tubes is 0.76.

Society of Automotive Engineers. S. A. E. Handbook. 2 v. 1918-1919.

Gives dimensions and torque capacities of seamless steel tubes, v. 1, p. 16-16b.

Specifications for Seamless Steel Tubing for Structural Purposes. 1910. (United States—Navy Dept. Specification, 44T1.)

Supersedes specification 44T1 issued May 12, 1909.

Speller, Frank N. Manufacture of Soft Steel Tubes in Relation to Corrosion. 1912. (In Journal of the Society of Chemical Industry, v. 31, pt. 1, p. 263-265.)

Includes a table giving comparisons of corrosion of boiler tube materials in aerated water and acid, and summary of corrosion tests on various materials in 25 per cent sulphuric acid. Includes cold and hot drawn open-hearth steels.

Speller, Frank N. Wrought Pipe—Threading and Relative Durability of Steel and Iron. 1905. (In Journal of the Canadian Mining Institute, v. 8, p. 46-55.)

Gives results of experiments on relative corrosion of wrought iron and steel pipes, and includes corrosion data on cold and hot drawn seamless tubes.

Spring, La Verne W. Non-Technical Chats on Iron and Steel and their Application to Modern Industry. 1917. Stokes.

Devotes a chapter to the manufacture of seamless steel tubes, p. 302-309.

Springer, J. F. Seamless Steel Tube Manufacture. 1910. (In Iron Age, v. 86, pt. 1, p. 612-618.)

Describes and illustrates the manufacture of seamless steel tubes. Discusses various processes including the Mannesmann, Stiefel, Charnock, Diescher, and principally the process employed by the National Tube Co. in making Shelby tubing.

Standard Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes. 1924. (In American Society for Testing Materials, Standards 1924, p. 212-218.)

The same. 1926. (United States—Bureau of Foreign and Domestic Commerce. Industrial Standards, No. 63.)

In English and Spanish.

Serial designation is A83-24. Covers lap-welded, and seamless steel and lap-welded iron boiler tubes, boiler flues, superheater tubes, safe ends and arch tubes.

Stang, A. H. Tests of Rotary Drill Pipes. 1921. (In Iron Age, v. 108, p. 804.)

Gives results of experiments and includes tests conducted on seamless iron pipes.

Steel Tube Process. 1898. (In Iron Age, v. 61, May 12, p. 10.)

Abstract of paper on a new process of making weldless tubes for cycles.

Steuer. Ueber die Herstellung nahtloser Eisenröhren. 1908. (In Eisen-Zeitung, v. 29, p. 835-836.)

Describes the method of seamless tube manufacture.

Stewart, J. G. Processes of Manufacture of Wrought Iron and Steel Tubes. 1915. (In Transactions of the Institution of Engineers and Shipbuilders in Scotland, v. 58, p. 212-249.)

Discussion. p. 249-256.

The same, without discussion. 1915. (In Mechanical Engineer, v. 35, p. 178-180, 203-207.)

The same, abstract. 1915. (In Iron and Coal Trades Review, v. 90, p. 608-610.)

Includes a description of the manufacture of weldless tubes, with a brief historical discussion.

Stewart, Reid, T. Strength of Steel Tubes, Pipes and Cylinders under Internal Fluid Pressure. 1912. (In Transactions of the American Society of Mechanical Engineers, v. 34, p. 297-312.)

Discussion. p. 312-318.

The same, without discussion. 1912. (In Mechanical Engineer, v. 29, p. 514-518.)

Author investigated and compared various formulas and found that Barlow's formula was best suited for all ordinary calculations pertaining to bursting strength of commercial tubes. Tabulates results of tests on seamless steel tubes, p. 309.

Stoughton, Bradley. The Metallurgy of Iron and Steel. Ed. 3. 1923. McGraw.

Treats very briefly of seamless tube making, p. 252, 253.

Tool Steel in Seamless Cold Drawn Tubes. 1903. (In *Iron Age*, v. 72, Nov. 5, p. 34.)

The same, abstract. 1903. (In *Machinery*, N. Y., v. 10, p. 199.)

Brief note on the production of tool steel seamless tubing by the Ellwood Ivins Tube Works.

Topical Discussion and Notes of Experience. 1898. (In *Transactions of the American Society of Mechanical Engineers*, v. 20, p. 427-439.)

Includes brief discussion on "What Constitutes a Seamless Tube?", p. 430-435.

Torka, J. Theorie des Mannesmann'schen Röhrenwalzwerks. 1888. In *Glaser's Annalen für Gewerbe und Bauwesen*, v. 23, p. 109-112, 132-136.)

The same. 1888. (In *Zeitschrift des Vereines Deutscher Ingenieure*, v. 32, pt. 2, p. 842-846, 863-868.)

Tschudi. Ueber nahtlose Stahlebehälter. 1892. (In *Glaser's Annalen für Gewerbe und Bauwesen*, v. 30, p. 205-207.)

Discussion, p. 207.

The same, abstract. 1892. (In *Stahl und Eisen*, v. 12, pt. 1, p. 443.)

Paper read before the "Verein fuer Eisenbahnkunde," dealing with the construction and durability of seamless steel shipping containers for acids.

Tube Making Machinery. 1898. (In *Engineering*, v. 66, p. 825, 826.)

Illustrated description of machines used for the manufacture of solid drawn steel tubes at the Alma Tube Works.

Tube Mill of the United States Projectile Company. 1897. (In *Iron Age*, v. 59, Mar. 18, p. 1-3.)

Illustrated discussion of the manufacture of cold drawn seamless steel tubing.

Tunner, P. Zum Mannesmann'schen Röhrenwalz-Verfahren. 1890. (In *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, v. 38, p. 291-293.)

Summarizes results of investigations of various authorities on the Mannesmann process of tube rolling.

Über das Mannesmann'sche Rohrenwalzverfahren. 1890. (In *Gesundheits-Ingenieur*, v. 13, col. 431-434.)

Treats briefly of the development and advantages of Mannesmann seamless tubes. Quotes several authorities on the subject.

Über die Verfahren zur Herstellung nahtloser hohlkörper. 1904. (In *Deutsche Mechaniker-Zeitung*, supplement to *Zeitschrift für Instrumentkunde*, v. 24, p. 102-103.)

Abstract of article in "Bayer. Ind.-u. Gewerbebl.," v. 36, p. 1.

Universal Tube Works. 1903. (In *Engineering*, v. 76, p. 492-493.)

Illustrated description of the Universal Tube Co. plant for the manufacture of small seamless tubes by the Ehrhardt process.

Unusual Products from Seamless Tubing. 1908. (In *Iron Age*, v. 82, pt. 1, p. 105.)

Brief note on various articles made from seamless tubing.

Varied Uses of the Seamless Steel Tube. 1910. (In *Iron Trade Review*, v. 46, p. 620.)

Illustrated description of uses of seamless tubes manufactured by the Detroit Seamless Steel Tube Co.

Verein Deutscher Eisenhüttenleute, Ed. Gemeinfassliche Darstellung des Eisenhüttenwesens. Ed. 11. 1921. *Stahleisen*.

Condensed treatment of several processes of seamless tube manufacture, p. 181-184.

Walker, J. Bernard. Story of Steel. 1926. Harper.

Gives brief history, various methods of manufacture and treatment of seamless steel tubes, p. 114-122.

Wedding, Herman. Progress of German Practice in the Metallurgy of Iron and Steel Since 1876, with Special Reference to the Basic Processes. 1890. (In *Journal of the Iron and Steel Institute*, v. 37, p. 491-560.)

Discussion, p. 560-563.

The same. 1890. (In *Transactions of the American Institute of Mining Engineers*, v. 19, p. 331-395.)

The same, abstract. 1890. (In *Scientific American Supplement*, v. 30, p. 12,393.)

Includes an illustrated treatment of Mannesmann process of seamless tube rolling.

Weldless Steel Pipes for Gas and Water. 1904. (In *Journal of Gas Lighting*, v. 85, p. 266-267.)

Werkzeuge aus Mannesmann-Stahlröhren. 1893. (In *Dingler's Polytechnisches Journal*, v. 289, p. 22-23.)

Abstract of article in "Metallarbeiter," No. 45, treats of the manufacture of various articles from seamless steel tubes.

Wilson, H. S. Production of Seamless Tubing. 1899. (In *Journal of the Association of Engineering Societies*, v. 22, p. 275-287.)

Discusses the kind and quality of the steel best adapted, and the method of manufacture of seamless tubes.

Wirthwein. Über die Herstellungsarten schmiedeeiserner geschweisster und nahtloser Rohre. 1901. (In *Zeitschrift des Vereines Deutscher Ingenieure*, v. 45, pt. 2, p. 1573-1574.)

Brief treatment of the manufacture of welded wrought iron and seamless pipes.

Wölbling, H. Zum Rostprozess der Guss- und Mannesmannröhren. 1913. (In *Ferrum*, v. 10, p. 161-167.)

Tests of steel and cast iron pipes under various conditions showed that for short periods iron pipes corroded more rapidly than steel pipes due to protective mill scale on the latter, while for long periods it was found that rust coating acted as a protection and the results were in favor of the iron pipes.

See also following reference.

Wölbling, H. Zur Rostung der Guss- und Mannesmannrohre. 1911. (In *Metallurgie*, v. 8, p. 613-617.)

States that the rapidity of rusting of cast iron, steel and wrought iron is in the order named, but the rusting of cast iron takes place more evenly while the other two rust in spots. Therefore the tendency is for holes to appear in steel and wrought iron tubes before they do in cast iron.

See also preceding reference.

Wolff, G. Verwendung von siliziertem und unsiliziertem Stahl zur Herstellung von nahtlosen Rohren nach dem Schrägwalz- und Pilgerschrittverfahren. 1925.

Wolfram, Ludwig. Seamless Tubing. 1921. (In *Metal Industry*, N. Y., v. 19, p. 112.)

Description of improved methods for the production of copper, brass and steel tubing.

Woodall, Henry, and Parkinson, B. R. Distribution by Steel with a Chapter on Main Testing for Leakage. 1911. Allan.

Brief treatment of weldless tubes, p. 119, gives tables of thickness of Mannesmann steel tubes in I.W.G., and lengths of solid drawn steel main with rigid joint, p. 128, 131.

(Concluded on page 192)

History of the Rolling of Rails*

A Review of the Development of Rail Sections from the Year
1857 to 1910—During This Period the Weight
Increased from 50 to 135 Pounds

By G. T. RAIDABAUGH†

IN the year 1857 the first Bessemer steel rail was rolled at the Ebbw Vale Iron Works, England. It was a double headed rail, but unfortunately there has been no record kept of its cross section. This rail was laid down at the Derby Station on the Midland Railroad and was in use for 16 years. History tells us that during that time 1,250,000 trains and a like number of detached engines and tenders passed over it.

The first Bessemer steel produced in this country was at a small experimental works established at Wyandotte, Mich.; the first steel made in the fall of 1864.

The first Bessemer steel rails ever made in America were rolled at the North Chicago Rolling Mill on the 24th of May, 1865, from ingots cast at the experimental works at Wyandotte, Mich., William L. Durfee, superintendent. The following extract from a letter by O. W. Potter to Mr. Durfee, in 1865, two days after the first rails were rolled:

OFFICE OF THE CHICAGO ROLLING MILL
May 26, 1865.

My dear Durfee:

I regret very much you could not have been here, particularly to see how well your steel behaved, and you should allow me to congratulate you upon its entire success. The hammer was altogether too light; of course, it took more time than it otherwise would to draw the ingot down, yet all the pieces worked beautifully and we made six good rails from the ingots sent over, and not one bad in any respect.

Yours,
O. W. POTTER.

I met with considerable trouble in my efforts to obtain a cross section of this rail, after writing to a number of the men who were prominent in the early development of the Bessemer industry in this country. I finally succeeded through the courtesy of D. S. Mathias, of the Illinois Steel Company, who in reply to a letter of inquiry says:

ILLINOIS STEEL COMPANY
South Chicago, Dec. 9th, 1904.

Dear Mr. Raidabaugh:

Your very interesting letter of Nov. 22nd received and contents carefully noted. I have prepared a blue print giving dimensions of the Delano and McLure rails, made by us for the C. B. & O. Railroad in 1888. The other section on the blue print is the iron section that they were rolling at the North Chicago Mills when they rolled the six rails that you speak of in 1865. They did not turn special rolls to roll the steel rails, but first used the same rolls that they rolled iron rails in. At the time these rails were rolled at the North Works, I was rolling at the Union Works and knew the above to be facts.

Yours truly,
D. S. MATHIAS, Superintendent.

James M. Swank, in his "History of Iron in All Ages," says that the first Bessemer steel rails rolled in the United States were rolled by the Cambria Iron Company at Johnstown, Pa., in August, 1867.

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†Sparrows Point, Md.

Through the courtesy of H. H. Weaver, of the Cambria Company, I received a print of the rail shown in Fig. 1, which is the first Bessemer steel rail rolled upon order in the way of regular business in America. This rail was rolled for the Pennsylvania Railroad Company from ingots cast at the Pennsylvania Steel Company's Works, Steelton, Pa. The ingots were cast about 8½ in. square and as their rail mill was not completed at that time the ingots were sent to the Cambria Works to be rolled into rails.

With the section shown we have hastily covered the period from 1845 to 1865. To this time we do not find that there had been any decided steps taken by our railroad engineers and officials towards improving the form of the rail. There had been a few efforts put forth in that direction, A. L. Holley being the most prominent of our engineers met with to this time.

In the year 1865, Ashbol Welsh began the work of improving the form of the rail and in that year designed a rail section very much like the one shown as the first Bessemer steel rail rolled upon order in this country.

Mr. Welsh said of this rail that he met with considerable trouble to place a contract for them as the rail makers were not inclined to risk the rolling of them on account of the thin flanges. Nearly 50 per cent of the metal is in the head of this rail. Mr. Welsh said at this he was in favor of placing 50 per cent of the total metal of the rail in the head.

In the year 1874 the idea advanced by Ashbol Welsh a few years previous to that time (that all the metal possible should be placed in the head of rail) began to take hold on our railroad engineers and in that year Octave Chanute published the rail shown as Fig. 2. This soon became a popular type of rails and we find that there were many different patterns of it made during the 20 years following. (See Fig. 3.) This is a later development of the Chanute rail, some of them with as much as 53 per cent of the total metal of the rail in the head.

In a short time rails of this time became known as the Chanute rail, but they were not without opposition as it was not a great while until these large headed and thin flanged rails started a controversy between the railroad engineers and the rail makers as to their merits and demerits, which continued for many years.

Notwithstanding the opposition of the rail makers, they became very popular with the railroads and there were many thousands of tons of them made and used since 1874, in fact, there are many of them in use at the present time.

The No. 2 (Fig. 3) rail shown is undoubtedly a descendant of the first Bessemer steel rail rolled in the United States with the flange somewhat thinner. It is a very interesting study to follow these rails through the various changes given to them, up to the year of 1892, when they culminated in the Pennsylvania Rail-

road standard 100-pound rail, which will be shown later.

At the time Mr. Chanute brought out his rail, the Chanute and Sayre rails were of the very few rails made to this time with a level on the side of the head.

It is a singular coincident that Mr. Chanute and Mr. Sayre should, without any knowledge of what each other was doing, arrive at practically the same results so far as the wearing surface of the rail head. The heads of the two rails were the outcome of a series of experiments and examinations of a large number of worn rail heads on the part of both men, and from this study of of them the two rails were designed. Some years later Mr. Forney designed a rail that had more level to the side of the head than either the Chanute or Sayre rail; these rails never became so popular as the Chanute rail, although there were some 10 or 12 patterns of them made and used, but at the resent time they are not in use to any great extent.

Mr. Chanute said at the time he designed the 60-pound rail (Fig. 2) for the Erie Railroad there was in use on that road 12 patterns of steel rail, 29 patterns of iron rail and 96 different styles of joint fixtures and rail fastening devices.

From this we can see how impossible it would be to attempt to show more than a few of the most

prominent types and patterns that were in use on our railroads.

At the 1888 meeting of the Institute of Mining Engineers, R. W. Hunt, one of the pioneers in the Bessemer steel and rail business, presented a set of series of rail sections as standard sections 60, 65, 70, 75, 80, 85 and 90 pounds per yard.

The seven sections were all of the same design and with nearly the same proportions of metal in the several parts of the rail as head, web and base. This close adherence to the one design gave to them as a series an appearance that could not be other than attractive.

This action on the part of Mr. Hunt in presenting this series of sections no doubt had an important bearing upon the adoption of a series of standard sections a few years later. As this was the first time in the history of our rail designing that a series of sections intended for that purpose had been presented in a practical and attractive manner, and was a decided advance over anything that had yet been done towards the end in view, that of originating a series of rail sections that could be accepted as standard rails by the railroad companies and the rail makers.

Mr. P. H. Dudley, a prominent railroad engineer, is one that has had experience such as comes to few men in the making and designing of rails. In the year 1883 he designed an 80-pound rail for the New

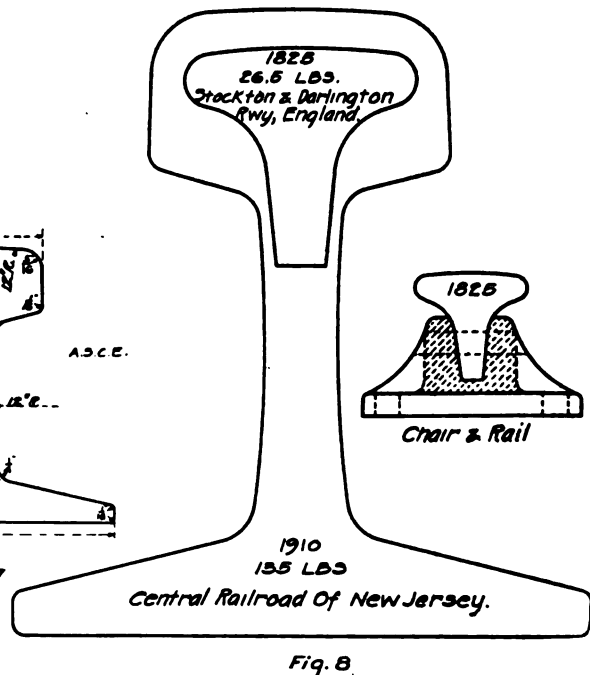
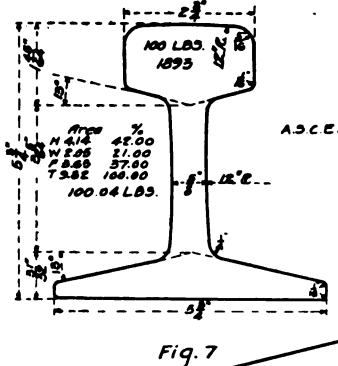
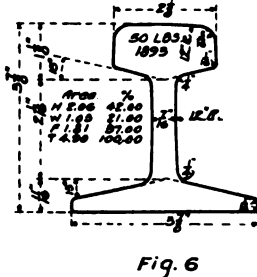
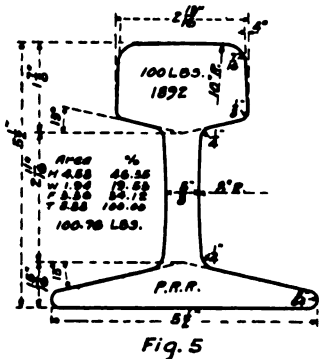
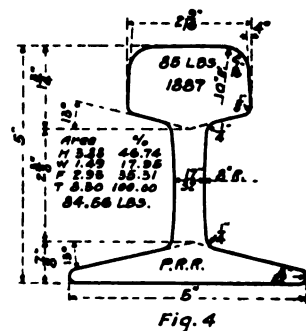
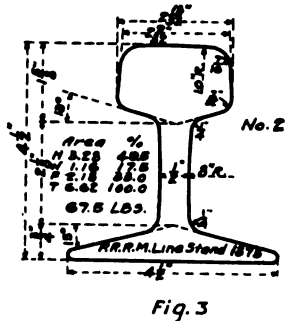
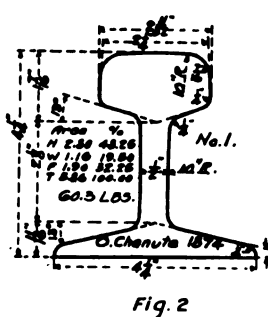
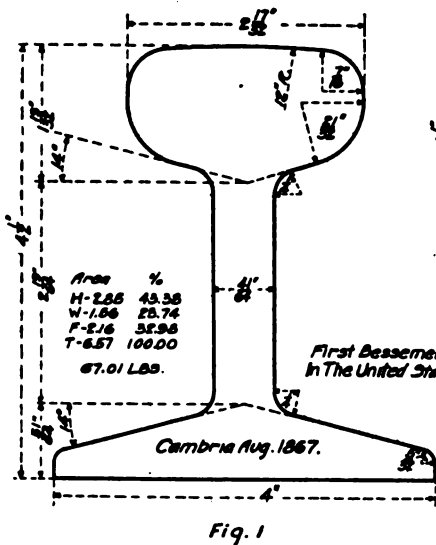


FIG. 1—First Bessemer Rail Rolled in the United States. FIG. 2—Octave Chanute Rail. FIG. 3—Modification of Rail shown in FIG. 1. FIG. 4—Pennsylvania Railroad 85 lbs. rail. FIG. 5—Pennsylvania Railroad standard 100 lbs. rail. FIGS. 6 and 7—A.S.C.E. rails of 50 lb. and 100 lb. section. FIG. 8—Central Railroad of New Jersey 135 lb. rail.

York Central & Hudson River Railroad. Mr. Dudley, at the 1890 meeting of the American Institute of Mining Engineers, said of the 80-pound rail that it was the pioneer of the broad and shallow head and thick base for heavy rails.

At the same meeting Mr. Dudley presented a paper on a system of rail sections in series, and said in designing the sections of rails, he had made five series, giving 15 sections of 12 different weights ranging from 50 to 105 lbs. per yard.

In the following year some of these rails were made and rapidly grew into fame. Since that time there have been many thousands of tons of them rolled and put into use, and are a popular rail at this time.

So far as we have been able to find out, Mr. Dudley was the first of our engineers to advocate the return to the use of rails with light heads and heavy base.

In the year 1887 the Pennsylvania Railroad Company adopted the 85-pound rail shown in Fig. 4 as their standard rail, and in 1892 the 100-pound rail (see Fig. 5) was made a standard rail by that company.

These rails were the Pennsylvania Railroad Company's standard up to October, 1907. During the time from 1887 to 1907, there were a great many used on the lines of that company. When we go back over the history of the rails used on the Pennsylvania Railroad lines we have no difficulty in tracing the origin of these two rails back to the Chanute rail of 1874. (See 60-pound rail in Fig. 2.)

We also find from a study of the development of the railway rail that with but few exceptions the rails shown on these pages have at some period in the past been in use upon roads that are now a part of the Pennsylvania system, and in addition there were quite a number of rail patterns of which we have a record that were in use on the Pennsylvania Railroad and lines that have become part of that system.

We have now come to the time when the most popular rail ever made, the American Society of Civil Engineers, A.S.C.E. rail, which was introduced in the year 1893. In the year 1885 that society appointed a committee to consider and report at a future meeting on the proper relation to each other of the rail section and car wheel. In 1900 this committee was supplemented by a later one retaining a number of the original members of the 1885 committee.

This committee was instructed to prepare and submit a report on a series of rail sections from 40 to 100 pounds per yard, with a difference of 5 pounds per yard between the sections.

It has been a very instructive and interesting study to read over the reports of these committees, submitted to the society during the eight years they were at work on this problem, and through the report to learn how and why they arrived at conclusions in developing the series of A.S.C.E. rails of which the 50 and 100-pound rail are shown in Figs. 6 and 7. These rails soon became very popular, so much so that by 1903 at least 75 per cent of all rails rolled in this country for home consumption were of this pattern, but the largely increased tonnage and higher speeds of our railroads began to tell on them and in the year 1907 new and improved designs began to come out.

The first of the new design of rail with the heavy base was brought out by the Pennsylvania Railroad Company who, on September 20, 1907, adopted the 85 and 100-pound sections. These two sections were designed by the engineer of that company and were

intended to take the place of the standard 85 and 100-pound rails shown in Figs. 4 and 5.

These rails were first rolled at the Maryland Steel Company Works, Sparrows Point, Md., on October 26, 1907; at that time there were about 45 tons rolled in order that some of the rails might be obtained for the purpose of testing the new designs. The tests proving satisfactory, there were rolled in December of that year, 2,000 tons of the 85-pound rail and about 4,000 tons of the 100-pound rail.

The operation of rolling these rail was of special interest to the railroad men and the committee that had been appointed to take up the study of the rail with the purpose of improving it.

A number of them were at the works at some period during the time they were rolled watching the various operations of manufacturing the rails, and submitting the finished rails to many and serious tests, which must have proved satisfactory from the fact that since that time a great many rails of this type have gone into use.

In the year 1907, the American Railway Association appointed a committee on rails; this committee reported in October, 1907, proposing two series of rail sections consisting of 60, 70, 80, 90, and 100 pound, one series A and the other B.

I do not think there were any of these rails rolled until 1908 and not a great many in that year, but by the early months of 1909, they began to be used quite freely. These rails are now known as the A.R.A. type.

These rails and the two P.R.R. rails give a fair representation of the changes that have been made in the shape of the rail since the crusade for a better rail began about the year 1904, but we are not prepared to believe that any change that can be made in the design of the rail will enable it to withstand the work imposed upon it through the increased speeds and heavy traffic of our trunk lines, except more metal is used and the weight of the rail increased to at least 125 pounds per yard.

The note in regard to the need of a heavier rail was first written in January, 1908, shortly after the first of the new design rails were rolled and being tested. In less than two years from that time the 135-pound rail, Fig. 8, was designed for the Central Railroad of New Jersey.

Several thousand tons of this rail have been laid in the tracks of this road, and other roads are beginning to see that it will be necessary to increase the weight of the rail.

The two rail sections (Fig. 8) are the first and last Tee rails made, covering a period of about 85 years. The small rail drawn in the head of the large one, Fig. 8, is the first rail rolled with a head, and was made in England, between 1820 and 1825, first used on the Stockton & Darlington Railway, which was opened for traffic in September, 1825.

The large rail, 135-pound section, the last development of the Tee rail. This rail was rolled at the works of the Pennsylvania Steel Company, Steelton, Pa., in the spring of 1910. It was first used upon the Central Railroad of New Jersey in 1910.

It has proved to be quite a task to classify and give to the early rails their proper titles, as there are many conflicting statements in respect to names given to the different rails by the early writers as they came

(Continued on page 197)

Recuperator on Open Hearth Furnace*

After a General Discussion of Furnace Operation with Regenerators the Application of Recuperators Is Described—
Leading Features of Recuperator Stressed

By W. H. FITCH

THE possibility of using recuperators for open-hearth furnaces has been a subject of discussion among operating men and engineers for several years. Those we have interviewed are divided into two classes: First, those who have waste heat boilers or prefer this means of utilizing waste heat; second, those who have no waste heat boilers and prefer to return all of the waste heat to the furnace, if possible, making it a closed cycle.

In the case of one large company, the claim is made that the use of electricity for driving mills and machinery is gradually reducing the usefulness of waste heat boilers, making the regenerator or the recuperator the only alternative.

As the recuperator principle is looked upon with favor in many instances, a general discussion of the subject at this time seems justified for the benefits that may accrue from an engineering standpoint.

We have not applied the recuperator design in question to an open-hearth furnace. We have, however, made an installation in which the temperatures are quite similar to the open hearth requirements.

The quantity of heat lost up the stack of an open-hearth furnace, operating under average good conditions, without waste heat boiler, is considerable. The average temperature of these gases in furnaces of a representative plant is approximately 1,400 deg. F. In the case of a 100-ton capacity furnace making a heat every 10 hours, and gasifying 600 lbs. of coal per ton of steel tapped, the possible avoidable loss of fuel per annum, (300 working days), up the stack is 4,320 tons coal. A reduction of temperature of gases from 1,400 to 700 deg. F. when entering the stack would be equivalent to a saving of 20 per cent of the fuel fired. At \$5.50 per ton of coal gasified, \$4.00 for coal delivered and \$1.50 for gasification, the savings would be \$23,760.00 per year.

In present practice, the temperature of air going to the furnace varies greatly. This must cause a loss of time in making a heat. If this temperature difference can be modified and an hour can be deducted from the time of making a heat, the results would be an increase of production. This value, added to 20 per cent fuel saving, would make a substantial total saving.

Practically all furnaces in service were built with gas and air regenerator at each end of the furnace. The checker volume of each probably average only 35 cu. ft. per ton of metal tapped.

In a number of plants, where furnaces were built with checker volume of accepted good proportion, the hearth has since been enlarged. As the checker volume could not be increased, the ratio of checker volume of ton of steel tapped has been reduced to a point that it is not economical.

In some small plants, furnaces have as low as 20 cu. ft. of checker space per ton of steel tapped. In

those cases the stack temperature is obviously comparatively high.

To change the construction of existing furnaces for increasing the economy would obviously be impracticable. To build a new furnace with the present type of regenerator, of sufficient capacity to return all of the desired waste heat to the furnace, would undoubtedly be so expensive as to be prohibitive.

The low efficiency of regenerators in service at the present time is recognized and understood by engineers.

The use of fuels of high calorific intensity have changed operating conditions so far as furnace design is concerned. Furnaces fired with coke-oven gas, tar and fuel oil do not require preheating of the gas. The preheating of air only is economically necessary. Indeed, a number of operators have expressed the opinion that it is not necessary to preheat producer gas where it can be delivered to the furnace ports at 1200 deg. F.

Where fuels are adopted that do not require preheating both gas and air checkers may be used for air only, thus substantially increasing the heating surface and temperature of air. Even under this condition, the total heating surface would not be sufficient in many cases to give the desired economical results. This last condition is the particular problem I am interested in and for which the following comments are intended.

The use of a recuperator, in combination with regenerators, is illustrated by Figs. 2 and 3.

Manner of Applying Recuperator

The recuperator is added to the present furnace without any change other than flue connections for reversing valves. There is sufficient space between regenerators in all furnaces that I have studied for a recuperator of the required size.

With the checker and recuperator combination the temperature of the air entering the checkers from the recuperator would be practically constant at 1,000 deg. F. At reversal the checker temperature on the end in question would be maximum. This would decrease in proportion to the decrease in temperature of air going to the furnace and until the economical heat transfer limit had been reached when the next reversal takes place. With 1,000 deg. F. air entering the checkers the variation in the temperature of the checkers, and consequently the air passing through, would be greatly minimized over air entering the checkers from the atmosphere direct. Advantageous results in the temperature of the furnace are apparent.

The use of a screen or checker chamber before the recuperator is desirable for the purpose of removing the oxides and dust, thus cleaning the gases before they reach the first pass of the tubes. The tubes will not deteriorate at any temperature found in practice of this kind.

Although several shapes may be used the tubular form is efficient for the flow of gases in recuperators.

*Paper presented before the Engineers' Society of Western Pennsylvania, October 28, 1926.

This type of construction is used in the recuperator under discussion.

The tubes, made of silicon carbide, are treated, protecting them from oxidation. This type of tube permits the maximum rate of heat transfer per square foot of heating surface per degree and hour. The tubes are made in one piece. There are no joints in the tube surface exposed to the direct action of the furnace gases, hence the possibility of leakage is reduced to the minimum. The tube ends are effectively sealed by cementing. The tubes are installed after the tube terminal walls are erected. The tube terminal walls are special shapes made of fireclay, and designed to facilitate the removal of tubes. This construction affords a chamber or compartment between tube banks large enough to admit a man for tube inspection and removal if necessary.

"Core busters," as shown in Fig. 1, are employed to compel the air to pass in contact with the wall of the tube. The "core busters" consist of solid cylinders made of fire clay. Legs are fitted for centering them in the tubes. "Core busters" are used in all of the tubes. They are made in three sections each 17 inches long. The center section is made of uniform diameter, while the end pieces are pointed to facilitate the flow of air into and out of the tubes.

The recuperator heating surface, illustrated in the open-hearth furnace, is approximately 7,500 sq. ft., or 111 sq. ft. per 1,000,000 Btu. fired per hour. This requirement is based on the gas from 500 lbs. of 13,500 Btu. coal entering the furnace per ton of steel poured, with temperature of furnace gases entering the recuperator at 1,400 deg. F and reduced to 700 deg. F. at the stack. A loss of heat equal to 100 lbs. of coal is estimated for gasification of coal. This recuperator capacity is based on what is being done with recuperators now in service.

The amount of heating surface in the total unit, regenerators and recuperator, is estimated to be equivalent to the cubical capacity of a regenerator of standard cross section area and 122 ft. in length. The difference in capacity of the present standard regenerator and the proposed combination is explained by the difference in the kind and thickness of the materials used in design of the recuperator.

Standard valves are shown. This illustrates the simplicity of applying a recuperator to an existing furnace.

Details of Recuperator

Referring to Fig. 1, the furnace gases enter the recuperator at point "A," and pass in one direction—around the tubes—to the stack "E." The furnace gases pass the tubes in a vertical column, thus utilizing all of the heating surface of the tubular members. The air for combustion passes through the tubes entering at "B," intermingling at "C" and leaving at "D." The combustion air flows continuously in one direction through tubes. After passing through the tubes the air is reversed from one end of the furnace to the other alternately as required.

How the construction of the recuperator influences the results as to uniformity of temperature of combustion air leaving the recuperator is evidenced by data given in Table I.

Two of these recuperators were installed in a double chamber car type kiln for the manufacture of face brick at the Summerville, Pa. plant of the Hanley Ceramics Company, about a year ago. Each half of the kiln has its recuperator, which is located about 150 ft. from the discharge end. The recuperators were designed for natural gas fuel and to deliver the waste gases to a dryer at about 500 deg. F. A complete illustrated article of this was published in "Brick and Clay Record," of Chicago, August 31, 1926 issue.

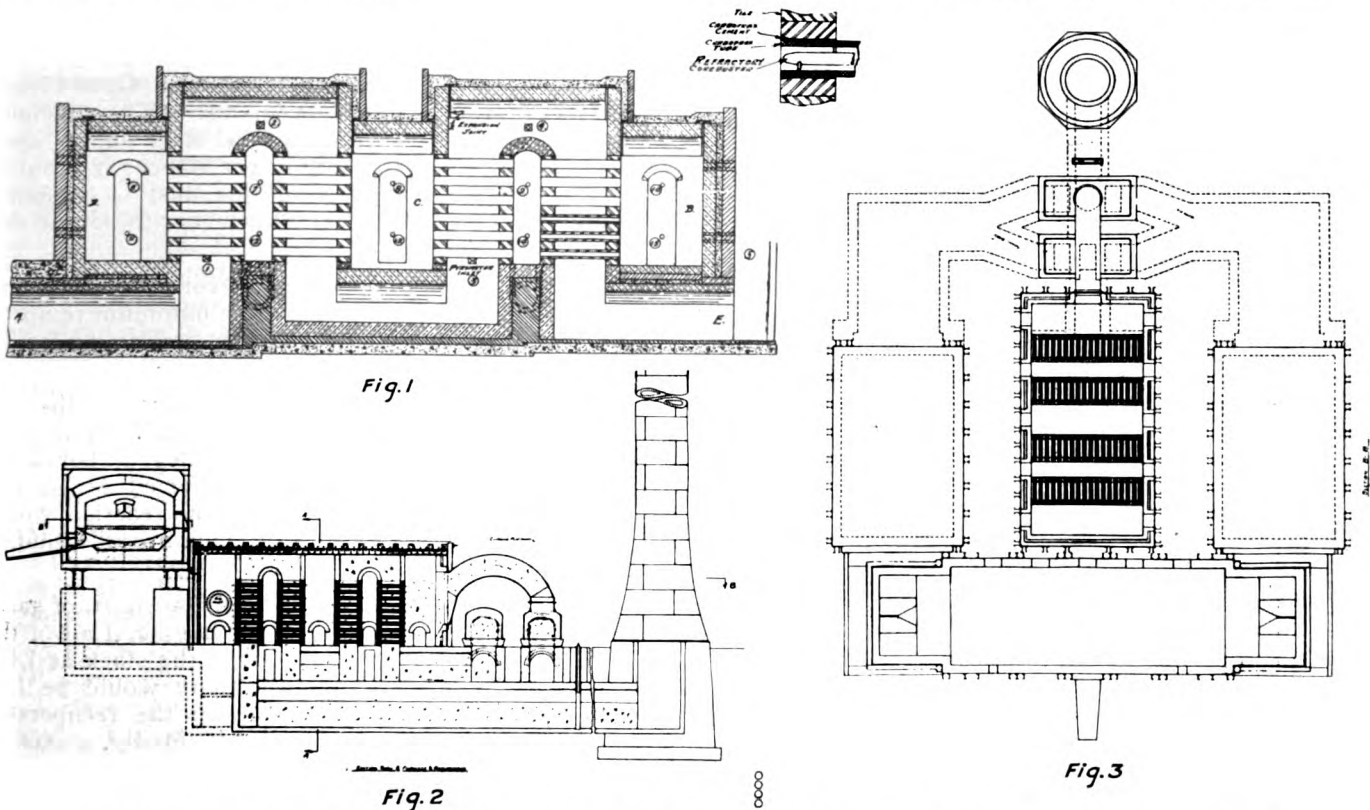


FIG. 1—Longitudinal Section of Recuperator—Core Buster at Right top. FIGS. 2 and 3—Application of Recuperator to Open Hearth Furnace.

It is interesting to note that the results of operating these recuperators compare favorably with the results obtained with metallic recuperators and that the use of refractory materials was not expected to yield results that would compete with the use of

TABLE I—HANLEY DATA

PREHEATED AIR		
	Temperature deg. F.	Draft in. water
Entering 1st pass	45	Plus .61
Entering 2nd pass	340 top	.47
Entering 2nd pass	275 bot.	.46
Entering 3rd pass	540 top	.38
Entering 3rd pass	530 bot.	.36
Entering 4th pass	755 top	.28
Entering 4th pass	720 bot.	.26
Leaving 4th pass	890 top	.16
Leaving 4th pass	890 bot.	.13
FLUE GAS		
Entering 1st pass	1290	Minus .26
Entering 2nd pass	1185	.29
Entering 3rd pass	1000	.45
Entering 4th pass	880	.51
Leaving 4th pass	610	.73

metallic substances in work of this kind and under similar conditions.

As a matter of fact the recuperators at the Hanley plant were designed for furnace gases entering the first pass of the recuperator at 2,000 deg. F., whereas this temperature has not exceeded 1,400 deg. F. approximately.

Eliminates Leakage

An interesting and important factor in the operation of those recuperators is that practically no leakage has been discovered between the passageways for furnace gases and combustion air, in recuperators that have been in service practically one year. This is undoubtedly due to the fact that the coefficient of expansion of silicon carbide is only slightly below that of fire brick; that the change in volume with change in temperature in this practice is almost negligible. Valuable data on the uses of silicon carbide will be found in Vol. 8, No. 5, May, 1925, of the Journal of the American Ceramic Society, by Messrs. Hartmann and Westmont. A study of the design of walls and roof housing the tubes is worth while. All gases are mechanically controlled.

There is not much difference of opinion among operators as to the advisability of using gases under pressure in the operation of a recuperator, if the design will permit. Production is the all important item. To have a furnace that can be put in operation quickly, and not dependent upon stack draft, is an advantage that is looked upon with favor.

In applying a recuperator to open-hearth furnace it is expected higher furnace gas temperatures than 1,400 deg. F. will be met with eventually, and after the true value of the recuperator is known. In the case of higher temperatures the rate of heat transfer will be much greater than found at 1,400 deg. F. However, this is an advantage, in that more work can be done per square foot of heating surface. The temperature that may be expected is not considered a problem, insofar as the decomposition point of silicon carbide is above 4,000 deg. F. There are no physical transformations at any temperature below decomposition. Certainly not at any temperature that may be found in practice of this kind.

In the event of a tube becoming damaged, the leakage of air would be a small percentage of the total and would mingle with the stack gases. In all probability it would not be perceptible, and the leak remain undiscovered until inspection period.

As it is necessary in present practice to repair furnace walls and roof, as well as clean checkers periodically, ample time would be provided for inspection of tubes, and the life of the recuperator could be prolonged indefinitely.

In applying a recuperator principle of this design to an open-hearth furnace for the manufacture of steel, the only limitation appears to be the quantity, temperature and nature of dust that may be deposited on the tubes. With 1,400 deg. F. temperature of furnace gases entering the recuperator the temperature of the walls of the lower tubes will not exceed 1,150 deg. F. in the first pass and an average of several hundred degrees for the recuperator, therefore, well below the temperature of the plastic state of dust, and consequently may be removed by the use of soot blowers as is the case in boiler practice. This method has proved effective where pulverized coal is used as fuel in boiler plants of modern design, and using coal of comparatively high ash content—600 lbs. of ash per hour projected into the fire box is quite common in this practice. If 20 per cent of this ash is precipitated on the tubes and settings, 120 lbs. would be removed periodically.

An open-hearth furnace fired with coke-oven gas and boiler fired with an equal value of fuel in the form of pulverized coal, per unit of time, is not an exactly comparative case, due to the difference in nature of the non-combustible substances found in the flue gases. However, if the quantity only is to be considered, the dust in the case of the boiler is many times that to be found in open-hearth furnace, and is comparative.

Referring to the paper read by Schroder and Larsen on "Progress Report Effect of the Open-Hearth Process on Refractories," we read: "The precipitation from the gases entering the stack of an open-hearth furnace is .05 to .259 g. per 100 cu. ft.; that by far the largest percentage of this dust is composed of iron oxide varying from 50 per cent to 95 per cent in different samples.

These particles have a severe corrosive action on silica and fireclay refractories—the minimum temperature range for this corrosion with fireclay and silica is around 2,500 to 2,600 deg. F."

The temperature of the furnace gases in the first pass of tubes would be about 1,400 deg. F. on an average as first explained, 1,100 to 1,200 deg. F. below the minimum corrosion temperature referred to; so one is justified in concluding that serious reaction would not result due to use of silica carbide in the manufacture of tubes.

On a basis of .259 g. deposit per 100 cu. ft. of gases and 6,000 lbs. of coal gasified per hour and all of the gases of combustion passing out of the stack at 1,400 deg. F. as in present practice, there would be 1.41 lbs. of dust deposited per hour on the recuperator tubes if it all stopped there. Undoubtedly, a smaller percentage is actually deposited and this removed at blowing intervals, an almost negligible quantity compared with results of boiler practice using pulverized coal as a fuel.

The Air Lift for Pumping Fluids

A Terse Description of a Method of Pumping Fluids Which Finds Application in Raising Water and Oil—Its Operation Explained and Costs Given for a Particular Installation

By H. T. ABRAMS*

UNTIL recently it was considered essential to an intelligent presentation of the subject of air lift pumping to give a complete history of its development. This situation does not exist today, as the air lift for pumping fluids and semi-fluids is now being universally used throughout the world, and historical references are merely background.

Originally it was applied almost exclusively to the pumping of water from drilled wells. Today its usefulness extends not only to water wells, but the same general principle of the air lift is being applied extensively to the pumping of oil wells, and bids fair to revolutionize past production methods in the oil fields. To the widespread introduction of "gas lifts" is ascribed the present high production in the mid-continent oil fields, and it will not be long before the ponderous, noisy, and wasteful methods of the past will be superseded by this new application of compressed air or gas. This method of pumping has also been applied to the unwatering of mine shafts, and for lifting mine tailing and ores; sand and water; dredging; and in the general service connected with the lifting of acids.

Simplicity is the keynote of the air lift. It is universally recognized as the simplest method of pumping known; in fact, were it not for its comparatively low thermal efficiency it would be used exclusively for raising water from subterranean sources.

The original promoters of this system hit upon its application in the simplest form, and nothing has happened in 33 years of experience to change the basic principles of operation. All improvements tending to increase the efficiency of the system have been brought about by a better knowledge of how to pipe wells to get the most economical results, and to the great improvements made in air compressing machinery.

Notwithstanding this situation, it appears that in many quarters there still remains a great deal of mystery about the system, and some confusion as to the principle of operation. One still hears of "blowing," "jetting," or "putting pressure" on wells, and, therefore, it may not be wasting time to discuss briefly the principle of operation.

Principle of Operation

We might start by defining the common terms used in connection with pumping wells. Reference is made to the diagram, Fig. 1—(Left).

Static Head. The distance the water stands normally below the surface of the ground.

Pumping Head. The distance the water stands below the surface of the ground when pumping the required quantity of water.

Submergence. The distance the pump, or foot piece, is submerged below the pumping head, that is, the distance from the pumping level to the air inlet.

Lift. The lift consists of the pumping head—the distance from the pumping level to the surface of the ground—plus any necessary elevation above surface.

Let us consider an open well into which we have suspended a pipe for water and a pipe for air. These pipes should be submerged to a certain depth proportionate to the lift when the pump is at work. It is clear that the water being free to enter the lower end of the pipe will rise to the same level inside of the pipe as it stands outside, and in this condition there will be nothing to cause any movement of the water either upward or downward. If we introduce air under pressure through an air pipe into the base of the water pipe, the effect after the first discharge of water from the pipe, which comes out en masse, is to aerate and reduce the weight of the contents of the rising main which are subsequently moved upward by the buoyancy of the air bubbles, aided by the greater weight of the solid column of water in the well surrounding the eduction pipe. The action as above described shows plainly the necessity for submergence, and explains why so much stress is laid on this requirement by those engaged in air lift work. Since it is the weight of an external solid column of water, termed submergence, opposed to a lighter column of mixed air and water inside the discharge pipe which causes a continuous stream to flow upward to the point of discharge, the necessity for the proper ratio of submergence to lift is one of the important and governing factors connected with the design of any pump and its ultimate efficiency.

In practice, the total lift, or head, enters largely into all calculations for air lifts. Very often the actual pumping level in a well, or group of wells, is unknown. However, it is possible to procure fairly accurate information from the well driller's test, or from characteristics of wells in the immediate vicinity. Frequently air is available for testing wells. When this situation exists, a very convenient and accurate method for obtaining the static and pumping heads is by the use of an accurate calibrated gauge. A globe valve and gauge should be placed on the air pipe near the well, the gauge to be located between the valve and the well. The length of the air pipe in the well must be exactly known.

The compressor should then be started, and when the water first emerges from the well the pressure should be read. This is called the starting pressure. After the well has been in operation for a time necessary to bring about normal operating conditions, the gauge should be read again. This reading gives what is known as the operating or working pressure. Then, proceeding, the valve should be closed, and the gauge watched closely. The pressure will fall and come to a stop, and at the time when the water ceases to flow from the discharge pipe, the pressure should be read again. This pressure at the momentary stop is what is known as the "shut in" pressure, and is the point where the head of water balances the pressure in the

*The Ingersoll-Rand Company.

air pipe. This reading should be taken several times so that an average may be made.

Arrangement of Apparatus

A typical arrangement of an air lift pump showing the pressure gauge and valve referred to is shown in Fig. 2—(Right).

As an example, take a well in which is installed 150 ft. of air pipe. Our gauge readings show:

Starting pressure 60 lb.
Working pressure 50 lb.
"Shut in" pressure 48 lb.

Converting pressure in pounds to feet, we have:

$60 \times 2.3 = 138 \text{ ft.} = \text{Starting submergence}$
 $150 - 138 = 12 \text{ ft.} = \text{Static head}$
 $48 \times 2.3 = 110 \text{ ft.} = \text{Working submergence}$
 $150 - 110 = 40 \text{ ft.} = \text{Pumping head}$

The lift, or head, being determined, the proper submergence should be taken so that good efficiency may be obtained. Extreme care should be given to

mind that in order to avoid the formation of large bubbles of air, which tends to drive through the water without doing their share of useful work and to induce as far as possible a condition by which the air can be thoroughly mixed with the water, the foot piece should be designed to divide the air into fine streams. Professor Harris in his book on Compressed Air says: "The slip of the bubble constitutes the chief loss of energy in the air lift. It varies with the square root of the volume of the bubble. It is therefore desirable to reduce the size of the bubble by any means found possible."

One of the best pumps on the market for accomplishing these theoretical results consists of an outer shell, or casing, with an inside tubing of brass, the pump proper being of sufficient length to permit a series of rings of small holes to be drilled around the periphery of the brass tube. These rings of holes are spaced in such a way as to create sufficient back pressure in the pump to prevent slippage losses, and to give control over admission of air to the rising column not possessed by any other type of foot piece on the market. The diameter of the inside mixing tube is from $\frac{1}{2}$ to 1 in. larger than the discharge pipe for which it is intended, and the Venturi connection between the mixing chamber and the discharge pipe gives the proper acceleration at that point.

Equipment at Plant

It may be interesting to relate the history of an air lift plant installed on Long Island. In June, 1923, there was put in operation at this plant an Ingersoll-Rand 100-hp. "PO" oil engine directly connected through flexible coupling to an Ingersoll-Rand 12 x 10 ER-1 compressor. From the flywheel of the oil engine there is also driven, through short belt attachment, a No. 5 "DV" Cameron pump.

This plant is pumping 520 gallons of water per minute against a total head of 234 ft. When pumping, the water stands 60 ft. below the surface, and is pumped by means of the air lift into a reservoir on the surface of the ground. The centrifugal pump takes the water from the reservoir and delivers it into a tank against a pressure of 75 lbs. gauge. It requires approximately 83 bhp. to do this work. The fuel oil consumed is 5 gallons per hour, and the oil is bought in drum lots at 8c per gallon, making the cost per hour 40c. The plant operates 16 hours per day, making a total of \$6.40 per day for fuel oil.

The plant supersedes and displaces a 60-hp. single cylinder horizontal kerosene engine directly connected to a 12 x 10 compressor, and one 25-hp. horizontal single cylinder kerosene engine direct connected to a 10 x 10 single acting vertical triplex pump. This plant had a capacity of 430 gallons of water per minute. Owing to the price of kerosene and starting difficulties, it was found advantageous to operate these engines on gasoline, the average price of which is 20c per gallon. The consumption was 7 gallons per hour, or a cost of \$1.40 per hour. Owing to the difference in capacity of these two plants, it was necessary to operate the old plant 19 hours per day, making a total of \$26.60 per day for fuel. The saving effected by the new oil engine driven plant is \$20.20 per day. On the basis of 365 days per year, which the plant operates, the net saving in fuel oil is \$7,373.

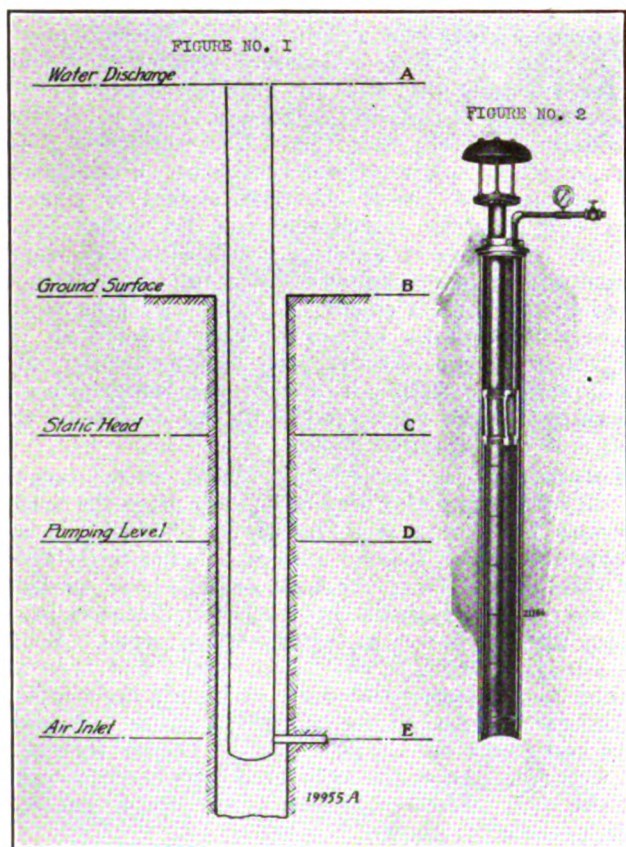


FIG. 1—(Left)—Manner of Installing Pump with Descriptive Terms. FIG. 2—(Right)—Section of Air Lift Pump.

the design of the eduction pipe as the success of an air lift depends a great deal upon this feature. The eduction pipe should be designed for the quantity of water being pumped so that the proper velocities may be maintained.

Having shown how the mixture of air and water in the discharge pipe is forced to flow upward, it is reasonable to conclude that all forms of ejectors and foot pieces have little influence upon the capacity or efficiency of the system as a whole except to bear in

The POWER PLANT

Results of Tests on Waste Heat Boilers

An Interesting Description of an Installation of Boilers on Three
90-Ton Open Hearth Furnaces—After a Service of
Nine Months Operation Is Checked

By MESSRS. EBNER and HAYES*

IN May, 1925, the United Alloy Steel Corporation prepared to meet an increase in steam demand of 1,000,000 lb. per day for use in pickling, heating and atomization of fuel oil in open hearth combustion. Steam at that time was costing \$0.37 per 1,000 lb., exclusive of fixed charges on boiler plant equipment. The possibility of producing steam at an equivalent cost of five cents per 1,000 lb. led to the decision to install waste heat boilers of the fire tube type.

Three 90-ton open hearth furnaces, located at the South Division Plant, Canton, Ohio, have been equipped with boilers designed for a normal operation of which the following data was available:

Metallic charge.....	210,000 lb. cold pig and scrap
Fuel consumption....	4,320 gal. oil per heat—19,000 Btu. per lb.
Time of heats.....	12 hrs. 42 min. tap to tap
Temp. of waste gases at base of stack.....	1200 deg. F.
CO ₂ in waste gases at base of stack.....	3.75% by vol.
Steam working pressure required.....	150 lb. gauge
Superheat.....	125 deg. F.

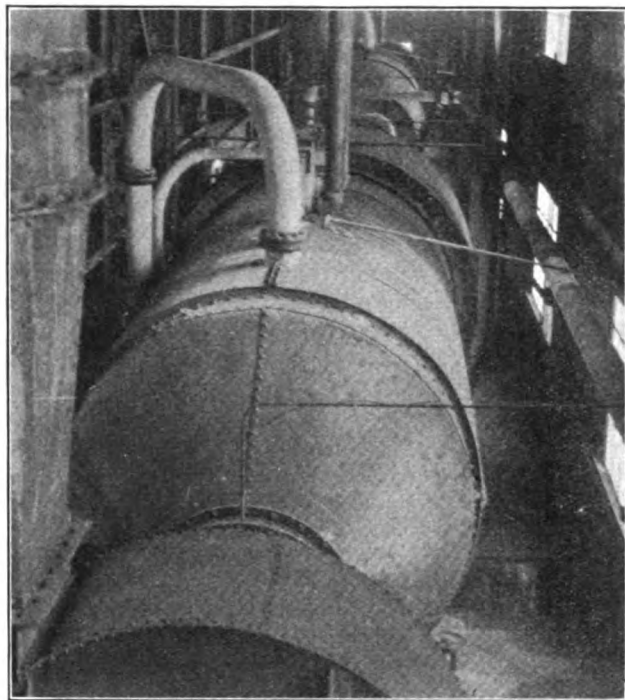
The design was influenced by the possibility of burning producer gas in the furnaces at times when fuel oil would not be available or the market price favored coal. It was further necessary to provide for direct firing of oil at the boilers to insure steam production regardless of continuity of furnace operation.

Consideration of these factors dictated a size of boiler to operate at best economy under normal furnace practice with oil fuel, in combination with an induced draft fan capable of handling the increase in combustion products under producer gas firing. Each boiler has 5,000 sq. ft. of tube heating surface contained in a shell 105 in. I. D. by 18 ft. long, built for a maximum working pressure of 160 lb. per sq. in. The shell lies horizontally, supported in two floor saddles at the elevation of the furnace charging floor.

Equipment in Units

Each of the three waste heat units comprises the boiler, superheater, auxiliary oil fired combustion chamber, induced draft fan, and flue and stack connections with dampers and valves. The waste gases are drawn from a point in the old stack flue through a vertical flue 22 ft. in length from cellar floor to centerline of boiler shell. A superheater with horizontal elements is located in the lower portion of this flue, and immediately above the superheater an opening is provided which connects with the auxiliary combustion chamber. Thus the waste gases from the open hearth furnace sweep directly across the super-

heater tubes, while the flame of auxiliary oil combustion imparts superheat to the steam only by radiation. The advantage of this arrangement is two-fold in that the degree of superheat is maintained fairly constant and the danger of burning the superheater is eliminated. The gases leave the vertical flue to



Waste Heat Boiler in Position.

pass directly into the tube of the boiler, where the velocity is increased to an extent required for producing turbulence in the gas stream, which is of greatest importance in securing high rates of heat transfer. Velocities much in excess of the critical, do not compensate for the resultant increase in draft loss which is reflected in power consumption of the induced draft fan. To secure a proper balance between gas velocity and draft loss is the problem of the designer, in which must be considered the possibility of faster driving of the furnace under mechanical draft.

The tubes and the front tube sheet are the only parts of the boiler making contact with the hot gases, the construction being similar to the locomotive type of boiler, forming a single pass for the gases to travel.

*Freyn Engineering Company.

Movement of the gases above their critical velocity through numerous small channels, and compulsory traverse of every pound of gas over effective heating surface, in combination are most efficient in promoting the transfer of heat by convection. The scrubbing action of the gas against the tube walls in which every particle functions has the added advantage of maintaining the cleanliness of the heating surface, as demonstrated in operation by the small amount of dust accumulation in the tubes.

Cleaning of Boilers

Provision is also made for dusting the tubes by means of a steam lance introduced through openings in the wall of the duct immediately in front of the boiler. The lance is moved by hand across the tube sheet and each tube is separately blown. The operation of blowing the tubes is accomplished in 10 minutes, and is done at eight-hour intervals by the water tender. It has been observed that the average reduction in stack gas temperature after dusting on the above schedule is about 15 deg. F., which indicates the clean condition of the tubes.

The boiler shells are covered with insulating blocks $2\frac{1}{2}$ in. thick and no brick settings are required. This is of advantage in reducing air infiltration, which is a common cause of loss in waste heat recovery. Brickwork even when new and well laid will not be free from air leakage, and the condition gets worse with time as walls develop cracks and the various door openings with their frames become warped and loose. The result is that air dilutes the products of combustion, causing reduction in temperature and at the same time adds to the weight of gas which the induced draft fan must handle at the expense of added power. The elimination of brick settings aids in reducing the cost of construction.

The gases pass from the boiler through a short steel breeching connecting to the induced draft fan, which exhausts through a connection to the open hearth stack. The fans are of the steel plate type, driven by steam turbines through speed reduction gears, and furnace draft is under the control of the melter, who can secure a wide range of draft intensity through regulation of the turbine speed. Exhaust steam from the turbine heats the boiler feed which is supplied by an open heater after treatment by a Zeolite softener.

All three waste heat units were in operation by January 1, 1926, after a five-month construction period from date of contract. They have been in service continuously, except for short periods of furnace shut-down. The latest operating figures available are for the month of October, 1926, and are as follows:

OPEN HEARTH FURNACES

Tons ingots produced—24 hrs.....	496.2
Average time of heats, tap to tap.....	12 hr. 5 min.
Fuel oil per ton ingots.....	49.6 gal.
Draft in stack flue under superheater.....	1.3 in. water

WASTE HEAT BOILERS

Feed water temperature.....	212 deg. F.
Steam pressure	126 lb. gauge
Superheat	110 deg. F.
Average temperature of gases to boiler.....	1050 deg. F.
Average temperature of gases to stack.....	492 deg. F.
Average evaporation 24 hr.—3 units	816,000 lb.
Evaporation per ton of steel.....	1,645 lb.
Average rate of evaporation—3 units	1090 bhp.
Average rate of evaporation—1 unit	363 bhp.

Average steam feed per hour to drive fan and boiler feed pump—1 unit	1,945 lb.
Per cent boiler evaporation to drive fan and feed pump	17.1%

The operating force consists of three water tenders, one for each shift of eight hours, and a helper, who is on day turn for 10 hours. These men operate the boilers, induced draft fans, water treating plant, feed pumps and heater. To date no other labor has been required since there has been no major item of repair or maintenance.

Separating Hydrocarbons in Coal Gas

Fractional distillation is an essential process in the analysis of gaseous hydrocarbons in coal gas, vapors of gasoline, and various other commercial gases and vapors, because the close similarity of the chemical composition of the hydrocarbons makes chemical analyses unsatisfactory. Fractional distillation has been found especially useful in determining the composition of coal gas in analytical work of the Bureau of Mines, Department of Commerce. A method has been developed in the Bureau's laboratories whereby the individual saturated and unsaturated hydrocarbons in coal gas can be accurately determined. It was found that the boiling point of the different hydrocarbons—methane, ethylene, ethane, propylene, propane, butylene and butane—mostly depends upon the number of carbon atoms contained in a molecule of the substance, and is affected very little by differences in structure and unsaturation. The method involves supplementing the usual Orsat analysis by fractional distillation, and can be applied to very small samples, only 50 to 2,000 cubic centimeters of the gas being required.

Seamless Steel Tubing; A Bibliography

(Continued from page 182)

Woodvine, G. R., and Roberts, A. L. Influence of Segregation on the Corrosion of Boiler Tubes and Superheaters. 1926. (In Journal of the Iron and Steel Institute, v. 113, p. 219-222.)

Discussion, p. 223-228.

The same, without discussion. 1926. (In Iron and Coal Trades Review, v. 112, p. 841-842.)

State that whether tube billets are pierced by a press or rotary piercer, blow holes and segregates, will if present, be found in interior of solid drawn tubes, unless ingots are made with all the care devoted to making high grade alloy steels. Give results of experiments to determine the extent to which pitting and general corrosion could be ascribed to segregated ingot material.

Wright, E. V. D., Jr. Belgian Seamless Tubes. 1925. (In Iron Age, v. 116, p. 1713.)

Being an abstract of report of United States trade commissioner on methods of Usines a Tubes de la Meuse. See also brief comment by E. R. Kelso, p. 1817.

Zobler. Verfahren zur Herstellung von nahtlosen Hohlkörpern. 1900. (In Zeitschrift des Vereines Deutscher Ingenieure, v. 44, pt. 1, p. 190-192.)

The same, abstract. 1900. (In Eisen-Zeitung, v. 21, p. 159.)

Describes method of seamless hollow tube manufacture by the Ehrhardt process.

Heat Balances in Industrial Plants*

A Clear, Comprehensive Discussion of the Utilization of Steam
with the Resulting Economies—Emphasis Placed
on the Part Played by the Turbine

By C. A. KELSEY†

SEVERAL years ago a vigorous campaign was launched to reduce waste in the generation, transmission and application of power in the industrial plant and for public use. The so-called "super-power" system was thought to be a great step in that direction, involving the generation of power in bigger blocks and the use of networks branching out into the country. The power companies could thereby produce power at such a low rate that a man could not afford to operate a private plant inefficiently—where the cost of power was higher than the price at which it could be purchased.

The public utilities, with the assistance of the electrical manufacturing companies, did make considerable progress in that direction. The size of the generating unit was materially increased and the heating cycles have been changed, so that more and more is being squeezed out of the Btu. in terms of electrical power. The transmission voltages have increased and, in that way, it has been possible to transmit power economically over greater distances and cover a greater range of territory. Thus most of the industries have been brought under the scope of the central station.

But there is a certain class of manufacturer which still continues to generate its own power. The use of central station power has not been complete. In the generation of electrical power in plants using process steam is found one of the notable exceptions to the tendency to go to central station power. There must be some good reason for that and this discussion will deal particularly with that phase of the subject. The generation of electric power in manufacturing plants employing process steam is steadily increasing in spite of the progress made by companies whose sole business is electric power service. One needs but to scan the technical press to learn of the large number of manufacturers that are combining their electric power production with their process heat or utilizing waste heat and fuel.

It is not only holding its own, but it is increasing. So if there is anything to that argument on the persistence of things in the face of a notion opposite to those facts, why it must be all the more reason for certain classes of industries to generate their own power.

Further evidence of the growth of industrial power in plants utilizing waste heat in the form of exhaust steam for process work is seen in the complete redesign of a line of turbines by General Electric to make the machine better adaptable to the wide range of operating conditions found in industrial power plants. The distribution between the high economy condensing and the non-condensing types has shown a marked change. Several years ago this company produced about an equal quantity of condensing and non-condensing units for industrial use. Now the produc-

tion of non-condensing and extraction types represent 75 per cent of the total. If the condensing units for waste heat utilization are included, the percentage amounts to about 90 per cent. The total production of industrial sizes up to 6,000 kw. has meantime materially increased and units up to 12,000 kw. should be included, because units of that size are now being used in waste fuel or waste heat plants.

Economic and Engineering Features

It would be well now to consider the economic and engineering features involved in the joint production of heat and electric power. Industrial heat balance implies an economic principle. The principle is that the joint production of heat in the form of steam and electric power shall be such that there is no useless excess of one or the other form of energy.

It means that heat in the form of steam and energy in the form of electrical power must be produced in such quantities so that there will be no excess of either, particularly, of course, of the steam. If there is an excess of electrical energy, it may be difficult for the industrial plant to find a market for it, because that is not its business. It is further required that the combined production shall be at the lowest cost for which it can be generated or purchased.

It is in meeting the last condition that great skill must be exercised. The facts applying to the future as well as to the present must be known. The present set of facts and conditions can usually be accurately determined, but the future conditions must in general be prophesied. By future conditions is meant such matters as permanence or expansion of the industry, methods of manufacture, improvements in design of the power and energy producing equipments and progress on the part of power producing companies. The cost of power generation is based upon a definite life of the machinery. If the method of manufacture should change, if the manufactured article or product be supplanted, if the power apparatus becomes obsolete or the cost of purchased power be materially reduced, the investment may not live its expected time and there may be a loss over a term of years.

That is one of the risks which the industrial plant runs in producing its own power, particularly if the apparent saving in producing its own power must be based upon a rather extended life of the apparatus.

With the facts applying to the present well in hand, it is a comparatively simple matter to effect a solution. Many large concerns have an engineering staff well capable of solving the problem. In the absence of such a force of engineers, there are a number of consulting engineers that specialize in the design and construction of efficient and economical industrial power systems. Then too the manufacturers of the machinery involved and the power utilities may be of assistance. The point to be emphasized is that in most cases the decision cannot be based on a general rule, but a careful analysis should be made.

*Paper presented before the Western Society of Engineers, Chicago, January 31, 1927.

†General Electric Company.

It is not intended to convey the impression that there are no general principles applying to point to the probable solution. There are certain industries requiring process steam where it is always cheaper to generate their own electric power, but a proper heat balance must be assured. On the other hand, it will rarely be found that the utilization of the exhaust from a prime mover for building heating alone will pay.

The generation of power by a fairly small steam turbine which is credited with the heat in the exhaust or steam extracted at some intermediate pressure between the throttle and the exhaust can be done at a far better economy than by the largest and most efficient condensing unit as now largely employed in central stations.

By that, of course, it is meant that, so far as the thermodynamics is concerned, if the heat of the exhaust is credited to a prime mover and then an attempt is made to see how many kw-h. can be gotten out of a given number of Btu. of steam, it will be found that the efficiency of conversion is very high. On the other hand, a condensing unit that must necessarily account for the heat in the exhaust is at a big disadvantage because of the large quantities of heat contained in the steam that goes to the condenser.

The Steam Turbine

A steam turbine operating non-condensing extracts heat energy from the steam passing through it equal to the mechanical power delivered to the shaft after deducting the external losses from radiation and the external mechanical friction. The source of energy for the most part is the latent heat of steam. The steam contributes a small amount of energy due to the sensible heat between the two temperatures corresponding to the limits of pressure of expansion. For conversion into electric power, the losses in the generator must be deducted. A kw-h. is equivalent to 3,412 Btu. The latent heat of steam at 212 deg. is 970.4. Four pounds of steam from and at 212 deg. F. will yield 3,880 Btu. Dividing 3,412 by 3,880 equals .88. An efficiency of .88 is a low figure to include the external losses of the turbine and all the losses of the generator.

It can thus be stated that a non-condensing steam turbine uses not more than the equivalent of 4 lbs. of steam from and at 212 deg. F. A high economy condensing unit of the central station type requires at least 10 pounds at high pressure, high superheat, and low vacuum. Reduced to the same basis, it requires about 12 lbs. It is thus apparent, the great advantage gained where the exhaust steam can be utilized in the process instead of being condensed.

If the heat in the fuel and then the furnace and boiler losses in the average industrial plant are considered, it is found that the steam passes through the piping, and there is a small amount of radiation, depending upon the size of the pipes, how far they run, etc. Then, the steam flows through the turbine. The turbine radiates some of the heat—a very small percentage, less than 1 per cent. The turbine external friction is less than 1 per cent.

The internal losses of a turbine may be considered also. The turbine buckets generate more mechanical power than is delivered to the shaft. That mechanical power is used up in the friction of the wheel and buckets in the atmosphere of the steam. And that, of course, restores to the steam the heat which was

taken out when it passed through the buckets. This loss, internal loss, is akin to an engine where there is cylinder condensation; the heating up of the walls at the beginning of the stroke and then the passage of the heat from the walls to the cooler exhaust steam at the end of the stroke, tending to re-evaporate some of the moisture in the exhaust steam.

Then there are the losses of the generator. And these, in the average industrial machine, might be 4 or 5 per cent.

Summation of Losses

Adding up all of these losses, external losses, it will be found that there is a small part of the total heat energy entering the turbine not in the exhaust steam. The exhaust is made up of steam and some condensate. The source of energy is the latent heat of the steam and some sensible heat, due to the difference in pressure and temperature between the two limits of expansion.

Industrial plants that use process steam generally have to use some live steam also, because it is impossible to balance up exactly at all times the exhaust steam from their prime movers and the steam demand in the process. In many cases they vary without any definite relationship. In other cases they have fairly close relationship. So it is usually necessary to bleed some live steam from the boilers into the exhaust system, which also tends to maintain the pressure in the heating or process system and keeps it from going below a certain predetermined amount.

Now whether a prime mover requires one amount of exhaust steam or another amount and the remainder is made up of live steam, the economy or the external losses are the same in either case—if the turbine or engine is simply being used as a reducing valve. And, generally, these machines make better reducing valves than the ordinary reducing valve, for a valve may stick, but the turbine or engine doesn't stick.

The same principle of extracting power from the steam applies to an extraction unit as it does to a straight non-condensing unit, because the steam that passes through the first stage and does not enter the second stage yields power from that steam at a high efficiency with the same transfer of heat equivalent to the Btu. in a kw-h. And then from the steam that passes through the turbine to the exhaust a great amount of power is extracted on about the same efficiency basis.

Turbines can be made with different stages; extraction operation can be arranged at different points; the turbines can be condensing or non-condensing, in the former type there are further stages at the back end. The turbines can be designed for high pressure and superheat in which case, the extraction opening is at lower stages. If a higher pressure is wanted, it can be selected at a suitable point. If a straight non-condensing machine is desired, such as a high back pressure machine up to 200 lbs., just a few of these first stages can be used.

Regulation of Turbines

These turbines can be regulated in different ways. The automatic control of the load, pressures, and quantities of extracted and exhausted steam has been perfected to meet a great number of conditions. The simplest form of automatic control is the maintenance of constant pressure at the extraction opening. This is accomplished by a pressure regulator controlling

through a piston the opening of the extraction valve. Temperature can be controlled in a heater by a thermal relay. The exhaust pressure can be regulated by controlling the pressure and hence the quantity of steam extracted at higher pressures. A combination of two turbines exhausting at high and low pressures can be used and controlled to maintain the pressure constant in either system by shifting the load from one unit to the other. Different degrees of speed regulation of extraction units can be met by the use of

a special form of speed governing mechanism.

Fig. 3 is a chart with the curves drawn to show the flow to the throttle corresponding to different extraction of steam at 100 lbs. gauge, and to show the flow of the throttle for given amounts of steam extracted at the lower pressures, which was normally, in this case, 50 lbs. to 60 lbs. maximum. The flow of steam is limited to the maximum flow of the turbine, at part loads, to the output of the machine, which happened to be 3,000 kw., and to the minimum flow to

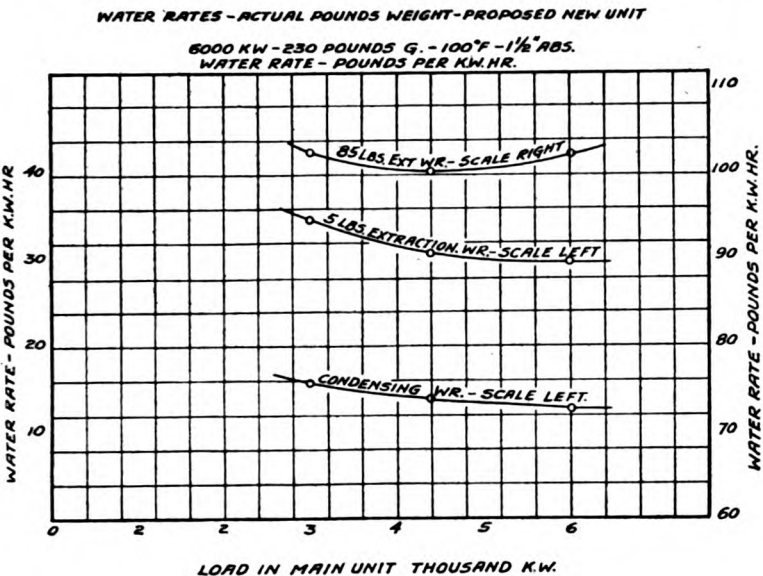


Fig. 1

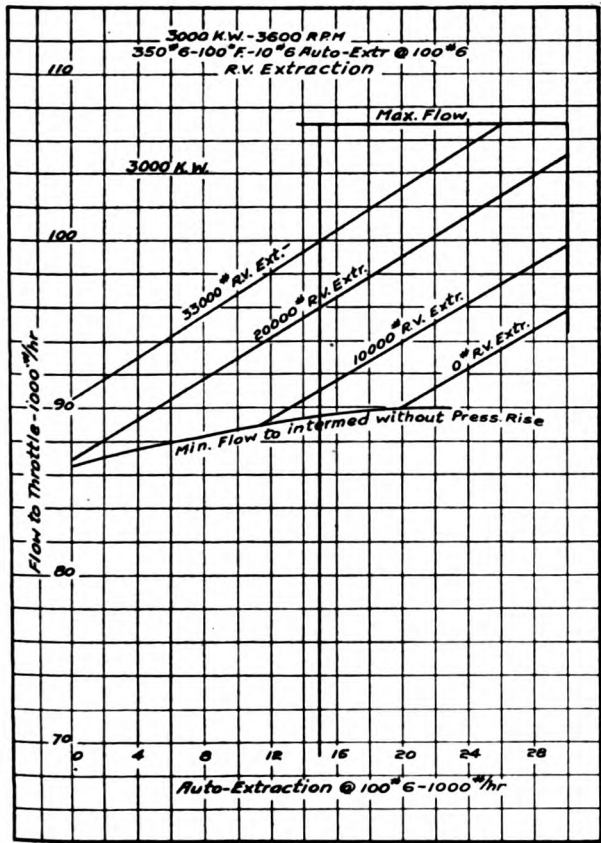


Fig. 3

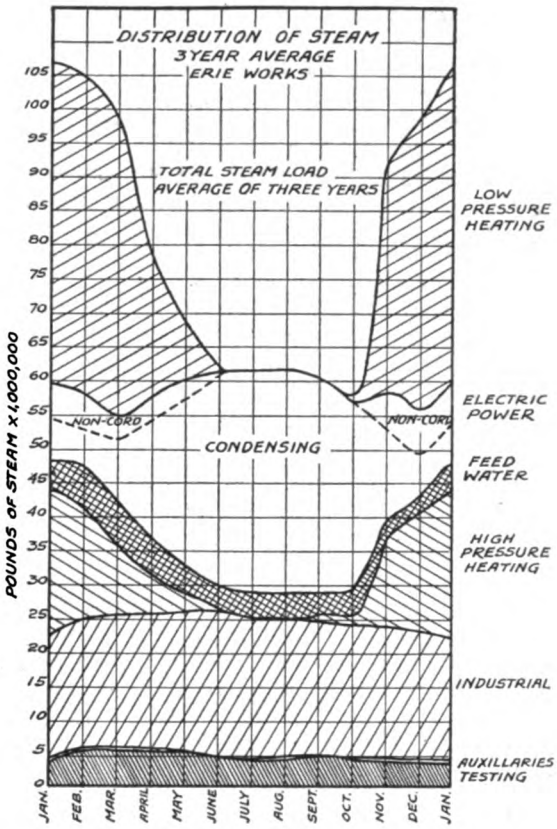


Fig. 2

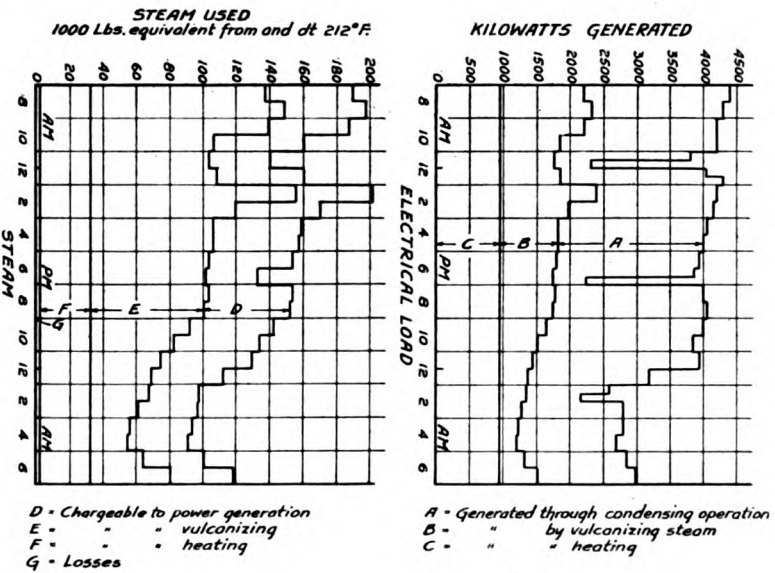


Fig. 4

FIG. 1—Relative Water Rates of Turbine at different pressures. FIG. 2—Steam Distribution in manufacturing plant. FIG. 3—Steam flow to throttle for varying amounts of steam extraction, FIG. 4—Power and Steam Demand in large tire mill.

the intermediate stage without an excessive rise in pressure. So there is a curve at the bottom, limiting the flow to the throttle for a given load and given condition of steam extracted at the two pressures.

The sum of the steam extracted at 100 lbs. and the steam extracted at whatever pressure resulting, as shown on the other curve, subtracted from the flow to the throttle gives the flow to the exhaust. These curves, sure to indicate the amount of work necessary on the part of the manufacturer for assisting the industrial plant and determining the type of turbine which can be used to give a proper heat balance.

Also, turbines can be furnished not only to regulate the quantity of steam extracted and for balancing up the pressure between the two systems, but also they can be provided with very sensitive governors for extraction machines, such as those required in the paper industry, where these machines are driven with motors. There must be no sudden change in the speed of those motors occasioned by the rise in voltage of generators resulting from possible speed increase or decrease. The paper would be torn. So there are governors developed which anticipate the decrease in output of an extraction turbine with the sudden demand for extraction steam, robbing the steam from the final stages of the machine. These governors momentarily increase the flow of steam at the throttle.

It is thus seen that the turbine manufacturer is prepared to design for almost any manner of operation that may be required by an industrial plant to meet its peculiar conditions. Good judgment must, however, be exercised in the selection of types, sizes and system of operation. Quite likely the first solution which gives an acceptable heat balance does not yield the lowest possible cost of operation. It may be desirable to make another study with changes in the sizes or types of the units or to provide for expansion at the least expense.

Boiler Performance

The boiler and furnace manufacturers are likewise prepared to contribute to the economy of power and steam generation in the medium sized industrial power plant. Boiler efficiencies have been raised by the improvements in the boiler itself as well as by the design of the furnace and accessories such as automatic stokers, oil burners, pulverized fuel, automatic firing boiler and furnace instruments and preheated air and feed water. The steam accumulator can be used to a limited extent to advantage for steadying the load on the boilers and thereby saving fuel.

One installation of the steam accumulator on this continent is in a refinery up in Canada. The steam accumulator was put on to even up the load on the boilers, and very highly efficient boiler house equipment was put in, and by being able to run the boilers at steady load, agreeing with central station practice, the company was able to get very high economy out of its whole outfit.

The determination of the cost of electric power and steam in an industrial plant can be influenced in a great measure by the view point of the engineer making the study. The overhead charges are much in dispute. The cost of supervision must be decided. The allocation of the cost of steam between that used for power generation and that chargeable to steam using processes should be equitably made.

Another phase of the general subject, but one which does not include a balance between process

steam and power, is the generation of electric power from waste heat and fuel. In this class are cement mills which have waste heat, lumber mills which have waste fuel and steel mills which have both waste heat and waste fuel. In these cases, the problem is to generate the maximum amount of power from the available heat and fuel. There must be available for these plants a suitable supply of condensing water. The conditions are not always ideal for making steam as in the case of large central stations, but the large amount of heat at the cost of handling only makes the generation of electric power profitable.

So far the general engineering and economic features have been dealt with. A few charts dealing with some details will now be considered. The first Fig. 2, shows the distribution of steam for different purposes in the generation of power in a large electrical manufacturing plant. It is an average curve drawn on the basis of three years' operation. Here, in the winter and fall months, it will be seen that there is a large amount of low pressure and high pressure heating. But there also is a good block of feed water heating and a rather steady demand for process work. And then there is a certain amount for testing. In this particular plant they manufacture turbines and much steam is required for testing the turbines. They operate their power plant condensing to carry the balance of the load over what is carried by the non-condensing units. In this case it is a rather small block of power that is carried straight non-condensing, but the low pressure heating and the high pressure heating are carried by the extraction condensing units. It is only in these cases where a large amount of steam is required and they have a rather steady load so they can use an extraction unit, that it pays to generate power in connection with a condensing plant. Furthermore, the plant must be fairly large.

Water Rates

Fig. 1 shows the relative water rates of the turbine in this plant corresponding to 85 lbs., 5 lbs. and condensing pressure. There are two scales here, one to the right and the other the left. It will be seen that the power generated on a condensing basis around full load is about 13 lbs. The water rate curve is fairly flat, and, at 5 lbs. pressure, the water rate is around 30 lbs., and that runs up a little bit sharper with decreasing load. Then at 85 lbs. it is 102 lbs., decreasing and again increasing with decreasing load. This chart is shown to give some mental picture of the relative amount of power that can be obtained at different extraction pressures where a nominal pressure and medium super-heat are employed.

The water rates will be about the same as these values for a given total load irrespective of how much load is taken out condensing, extraction, or any combination of these. The water rate will be governed very largely by these curves.

Fig. 4 shows the varying power and steam demand throughout a normal working day in a large tire mill. Power is generated from all of the process and heating steam and the balance of the power is generated condensing. A study was made of the average power costs for this mill for a 4,500-kw. and a 10,750-kw. load under steam conditions of 185 lbs. pressure and 150 deg. F. superheat and 275 lbs. pressure and 200 deg. F. super-heat in each case. The power units were augmented in each case for the greater load. The cost of power dropped from 1.124 cents per kwh. to 1.100 cents for the smaller plant and from .997 cents to .977

cents for the larger plant with the better steam conditions. That means that in each case the saving or the reduction in cost of power was only about 2 per cent, for the betterment of the steam conditions, whereas the cost of power in going from the smaller plant to the larger plant—which, by the way, included more use of extraction steam—was quite a few per cent better.

This curve also illustrates some other points. It will be seen that there is quite a bit of condensing load. There is a block of vulcanizing steam which is extracted at around 80 lbs. And then there is heating steam, that is based upon a normal working day and on 30 cold days. The power record was taken in February, 1922. The upper curves show the kw. generated for those different quantities of steam and the curves below show the amount of steam from which the power was generated. The curves show that power was generated from the process steam to the limit and the remainder supplied by condensing units. But the reason it was necessary to generate a considerable amount of power by condensing is because of the shape of load curve. The supply of process steam cannot be regulated to agree with the demands for electric load, so it was necessary to generate part of the power straight condensing, part extraction, and part non-condensing.

There are certain industries which fall rather clearly into different lines, where power can be generated economically; where power can't possibly be generated so cheaply as it can be purchased, and then there is the class in between where the ability to generate power economically is dependent upon a good many factors which must be given very careful study. There can be no set rule, the cases must be worked out in detail. And even under those conditions, it is very difficult to determine the facts which will be permanent enough in that particular industry to warrant an outlay which must be written off in 15 or 20 years.

The sugar mill is one exception where it can be said that it is possible to design a mill, either a beet or a raw cane sugar mill, or a refinery, so that it can produce its own power cheaper than it can purchase it. And there are cases where cement mills can generate practically all of their power, and in many cases they can make all of it from waste heat.

And then the steel mills can be considered with their blast furnaces. They have enough waste fuel and waste heat to generate a large portion of their power.

But if a power plant is installed for the purpose of generating power and building heating, it generally will not pay. There are other mills that have other characteristics, such as paper mills, that can generate their own power, and it might be said that if they purchased all of their power they could not make it pay. Oil refineries, also, use much process steam, and in some cases they are able to deliver considerably more power than is required in their plant from the process steam, particularly if that steam pressure is elevated and super-heat is used.

The artificial silk mills require a lot of process steam and they can generate practically all of their power. The textile mills, particularly the finishing mills, are in that class, also. A number of rubber mills have their own power plants, but the most of the steam in a rubber mill is required at fairly high pres-

ures, and it is generally difficult to get by with a straight non-condensing unit. But they use so much power that they can afford, in some cases, to have their own power plant, which becomes of such size that it is almost like a central station. It is said that some of the mills near Akron got together and financed a central power plant, for the use of all of them.

History of the Rolling of Rails

(Continued from page 185)

out. We have endeavored, as far as possible, to get the names correct.

The first rails, as we all know, were wood or timber rails. These early wooden roadways were called tramways, this name coming from a Mr. Outram, who was extensively connected with the early roads. The transition from Outram to tram, being short, was easily made.

The first iron rails were of cast iron cast in the form of flat bars, and were called plate rails, hence the English railway term plate layers. Later when flat rails were rolled out of malleable iron they received the name of strap rails, but never entirely lost their first name of plate rail, which was occasionally given as long as they continued in use.

The next rail to come into use after the plate and tram rails were the cast iron edge rails. Later, when edge rails were rolled from malleable iron they were first given a different shape, and the name changed to T rail; this name continued in use until the double head rail came out, when the name was again changed to single T rail. It was at first called the double T rail, but is now universally known as the double head and bull head rails.

There have been in the past, as well as the present, many other names given to the rails. Among the early rails we find the Birkenshaw, Clarence Stevens and Lock. Later the Welsh, Chanute, Hunt, Dudley and A.S.C.E.

But the titles as given above of wood, plate, strap, tram, edge, single T, double T, double and bull head H rail, bridge and tee, covers all the various forms and types of rails that have been in use upon steam railways; at this time, all of them except the double head bull head and tee rails have gone out of use.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, ETC., OF

The Blast Furnace and Steel Plant

(Required by the Act of Congress of August 24, 1912)

Name of Publication: **The Blast Furnace and Steel Plant**, published monthly at Pittsburgh, Pa. (Report of April, 1927.)

Publisher—The Andresen Co., Inc., 108 Smithfield St., Pittsburgh, Pa.

Editor—Donald N. Watkins, 108 Smithfield St., Pittsburgh, Pa.

Managing Editor—Charles Longenecker, 108 Smithfield St., Pittsburgh, Pa.

Business Manager—Donald N. Watkins, 108 Smithfield St., Pittsburgh, Pa. Names and addresses of Stockholders holding 1 per cent or more of total amount of stock:

Donald N. Watkins, 108 Smithfield St., Pittsburgh Pa.

C. J. Keller, 935 Heberton Ave., Pittsburgh, Pa.

M. M. Zeder, 108 Smithfield St., Pittsburgh, Pa.

Known bondholders, mortgagees, and other security holders holding 1 per cent or more of total amount of bonds, mortgages, or other securities: None.

DONALD N. WATKINS, Business Manager.

Sworn to and subscribed before me this 22nd day of March, 1927.

CHAS. A. SEIBERT, Notary Public.

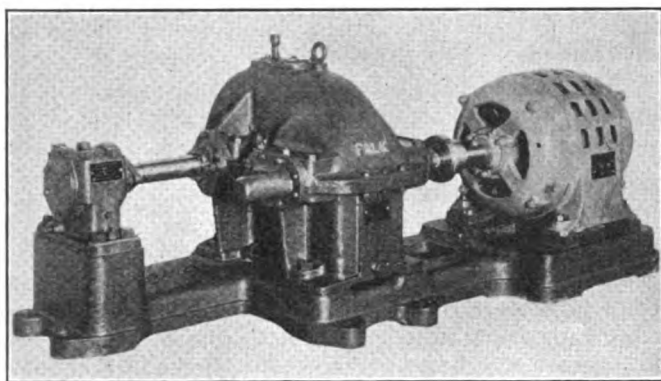
(My commission expires March 6, 1931.)

WITH THE EQUIPMENT MANUFACTURERS

The New Falk Speed Reducers

The Falk Corporation has brought out a new line of speed reducers. These units feature the Falk continuous tooth, all steel herringbone gears. Like the units previously built by this company, the gears are precision made, silent and give high efficiency.

Special design of housing eliminates any internal ribs, projections or complicated cores. Lubrication has in this way been simplified and all possibility of dirt or core sand working into the gears is definitely



removed. Added features are the airplane type, steel backed, babbitt-lined bearings that are capable of carrying heavier loads and an improved automatic continuous lubrication system.

Based on years of experience, this line covers a certain number of standard reduction ratios. Standard motor beds have been adopted for these units. Standardization of units and beds in accordance with general industrial demands makes possible stock delivery of this precision product.

The reducers are made in three types—single reduction for ratios up to 9:1, double reduction for ratios up to 70:1, and triple reduction for ratios up to 300:1. A double reduction unit No. 7D is shown in the illustration.

New Nuttall Helical Gear Speed Reducer

The R. D. Nuttall Company, Pittsburgh, Pa., have recently developed and placed on the market a complete line of speed reducers, which incorporate in their design Nuttall $7\frac{1}{2}$ deg. helical gears and Timken tapered roller bearings. This series of speed reducers is known as the SVR series and covers a range of from 1 to 150 horsepower.

The SVR series are single reduction units, with reductions ratios ranging from 1 to 1 to 8 to 1; the high and low speed shafts being parallel and offset in the same plane.

The Nuttall Company has been building gear units for several years, using in their construction helical gears and Timken bearings, and the universal success of these units has lead the company to design and develop a complete line of speed reducers. Helical

gears have numerous advantages over other types of gearing, they drive with the smoothness of a worm and worm wheel, yet have the high efficiency of a spur or herringbone gear; they have greater strength than spur gears and are equally strong as herringbones, besides having wearing qualities superior to either of the other types. One of the greatest advantages of helical gears is their ability to resist external thrust.

Timken tapered roller bearings insure absolute bearing dependability, combined with maximum efficiency. They hold the shafts in positive alignment and may be readily adjusted for wear.

Shafts in these reducers are carbon steel forgings, with the pinions integral. They are oil treated to give them additional strength. To correct any possible distortion caused by heat treatment the pinions are given a finish cut and the shafts are ground to close limits. In installations where loading requires, shafts and pinions will be made of alloy steel. The reducer case is cast from the best grade grey iron, and is carefully assembled to reduce the possibility of oil leakage to a minimum.

A positive system of splash lubrication assures a good supply of lubricant to all the bearings and a protective oil film on the gear teeth at all times. The bottom of the case serves as a reservoir for the oil, which is picked up by the gear teeth and thrown by centrifugal force into oil troughs, through which it is lead to the bearings. Adequate return ducts are provided for the oil to drain back into the case and thus prevent leakage around the shafts. A settling basin is provided in the bottom of the case giving a chamber into which sediment in the oil can settle, thus increasing the efficiency of the lubricant.

Novel Type of Hammer

The replacement of labor with machinery is going forward with immense strides, being directed now into many channels of industry heretofore regarded as not worth changing over. One of the latest types of devices for labor saving is the Blacker "B" blacksmith hammer, which performs every operation that any type of hammer can, and in addition, the thousand and one operations of hand forging, impossible to any other type of hammer. The Blacker Engineering Corporation, Grand Central Terminal Bldg., New York, is meeting with well merited success with its blacksmith hammer, for it fills an important niche between the hand anvil operation and the ordinary types of power hammers. The type "B" requires no special tools, dies or fixtures, using only the ordinary hand anvil tools to which the smith is accustomed, eliminating the human element of strikers and helpers. The use of the type "B" requires fewer heats and the speed of operation is uniform, both on light and heavy work—140 blows per minute, the limit at which the smith can handle the tools, with absolute positive control of hammer blows. Many of the forging plants and machine shops in the steel industry are equipped with a number of the Blacker "B" hammers.

Improved Arch Construction

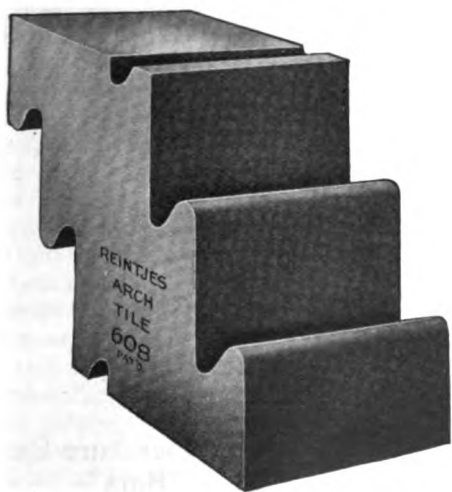
A flexible arch tile enabling more economical and much easier arch construction and maintenance, created considerable comment upon being displayed at the Chicago Power Show.



The new patented Reintjes flexible arch tile forms its own arch, requiring no temporary arch centers or skewbacks. No iron or steel required either. Only two shapes of tile are needed regardless of thickness of walls or the varying width of span, or whether the door jambs are square or beveled. This eliminates the need for several styles needed heretofore.



Another feature of the Reintjes flexible arch tile is that no leveling is required as is necessary with sprung arches. The units remain level with adjacent brickwork without any leveling medium. Each step up is equal to a brick course. The arch is built up in sections the width of one brick course.



The tapered key of Reintjes flexible arch tile facilitates repairs. Replacement arches can be driven to a tight fit without disturbing overhead brickwork. The interior section of the arch can be repaired without interfering with the remaining sections.

Reintjes arch tile is ideal to improve arch construction in firing doors, observation doors, relieving arches of side walls, Chicago combustion arches, rear arches

H. R. T. boilers, roof arches for any type of furnace, bridge walls with or without waterback, roofs of gas flues, etc. In fact, Reintjes arch tile is very flexible in its use, serving practically every arch purpose.

This patented arch tile is being marketed by George P. Reintjes Company, 2517-19 Jefferson Street, Kansas City, Mo. Additional information will be gladly given upon request.

TRADE NOTES

The Wm. B. Scaife & Sons Company has distributed very attractive announcements calling attention to the fact that the company this year celebrates its one hundred and twenty-fifth anniversary, as it was established in 1802.

* * *

Frey Engineering Company of Chicago advises the completion of arrangements whereby the following companies are licensed to manufacture and sell Beaton tuyeres: Dixie Brass & Foundry Company, Birmingham, Ala.; Falcon Bronze Company, Youngstown, Ohio; Hodgson Foundry Company, Chicago, Ill.; Keystone Bronze Company, Pittsburgh, Pa.; Lawrenceville Bronze Company, Pittsburgh, Pa.; Smeeth-Harwood Company, Chicago, Ill.

* * *

Midland Steel Company, Cleveland, has elected the following officers and directors: President, E. J. Kules (re-elected); vice president, R. H. Clark (re-elected); vice president, Gordon Stoner; treasurer, F. K. Conrad; secretary, H. F. Kulas. Directors are P. W. Brown, George A. Coulton, F. H. Ginn, E. H. Kulas, H. C. Sherrard, F. W. Paine and F. F. Tillotson. L. Kemper has resigned as vice president of the Midland company and treasurer of the Otis Steel Company, Cleveland, as of March 31.

* * *

Gathmann Engineering Company, Baltimore, has booked an initial order for 3,000 sink-heads from the Jones & Laughlin Steel Corporation, to be used at the rate of 200 per day. Youngstown Sheet & Tube Company now is using these exclusively in casting approximately 10,000 tons of ingots per month for its new tube department. It is stated that as a result of this practice, the Youngstown company is getting a yield of 82 to 83 per cent in its ingots. In addition, the Bourne-Fuller Company, Cleveland, is using the device at the rate of 150 to 175 daily. These sink-heads are manufactured from a mixture of slag and cement. Gathmann Engineering Company now has plans under way for increasing the output.

* * *

The Philadelphia Office of the Blaw-Knox Company has removed from the Colonial Trust Building to 332 Widener Building in Philadelphia.

Correction

In the February issue under the heading "Data on Power Plant Equipment Used at Blast Furnace of Mystic Iron Works" the stokers accredited to this plant are listed as of Harrington make. This is an error as they were of the Green Forced Draft type.

THE STEEL PLANT BRICK MASON

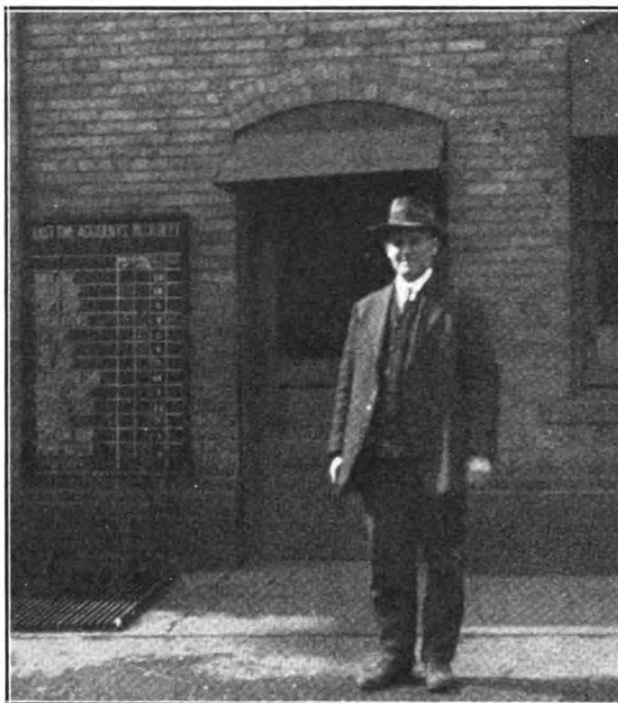
A Section Devoted to Items of General Interest to Blast Furnace and Steel Plant Brick Masons

Heat Resistant Whitewashes to Be Described at Chemical Society Meeting

The results of an extensive series of tests conducted to develop an economical and durable heat resistant water paint or whitewash will be presented at the Richmond meeting of the American Chemical Society. The paper, by E. P. Arthur, formerly of the staff of Ohio State University, is part of the Symposium on Lime to be held by the Industrial Division, April 13 and 14.

At various points in practically all industrial plants there is a need for surface coatings which will withstand temperatures above those which destroy ordinary oil paints. Large numbers of such coatings have been recommended, but objections may be found to most of these on the basis of cost, ease of application, light effects or durability.

The refractory properties of lime and the whiteness of films obtainable with whitewashes led to a study of the possibilities of adapting such coatings for use on surfaces subject to high temperatures. Very satisfactory results have been obtained and formulas have been developed which produce films that are standing up after months' exposure under severe conditions. The fields for application of these high temperature whitewashes and the details of these investigations will be of direct interest to all industrial chemists.



Mr. Peter Isles, who is shown standing outside his office, is one of the best known brickmason superintendents in our many steel plants. For 32 years he has seen service as a brickmason, or has directed masonry construction, at the Homestead Works of the Carnegie Steel Company, hence he may rightfully be termed a pioneer at the trade. As this Works has four open hearth plants, together with many mill furnaces, soaking pits and boilers; Mr. Isles has a job of some magnitude.

am employed. I wish you would tell me why brick "spall"?

E.M.D.

Answer—This is a difficult question to answer in the small space allotted. I would suggest you write for copies of "A General Theory of Spalling," by F. H. Norton in Vol. 8 of the Journal of the American Ceramic Society, and "A Study of the Spalling Test for Fire Clay Brick," by M. C. Booze, on page 277 of the Proceedings of the American Society for Testing Materials for 1926, Vol. 26.

The firebrick work for the new Mystic Furnace, at Everett, Mass., which involved the laying of 1,800,000 9-inch equivalents, was performed completely in the record time of 90 days. The power plant, on which brickwork was started about the time the furnaces and stoves were finished, required the laying of another 1,500,000 bricks and was completed in 100 days. This entire work was carried forward through a severe New England winter. The Shea & Whelpley Construction Company, of Cleveland, O., were the contractors for this work, and to them is given the credit for this record performance.

The American Refractories Institute, Oliver Bldg., Pittsburgh, Pa., has compiled the seventh edition of

a booklet, "Brands of Fire Brick and Other Refractories." This booklet contains a list of the manufacturers of fire brick in the United States and Canada, together with the brands of brick each manufacturer produces. The various companies are also indexed by states and plant location.

The Refractory Question Box

The Blast Furnace and Steel Plant Brick Mason will be glad to answer questions of a practical nature on the use of refractory materials in general steel mill practice. Questions pertaining to any particular brand of refractory will not be answered.

The Brick Mason,
Blast Furnace and Steel Plant,
Pittsburgh, Pa.

Dear Sir—I have been a subscriber to The Blast Furnace and Steel Plant for six years and I am pleased that you are giving some attention to refractories. I have a lot to do with such work in the plant where I

Mixture of a High Temperature Cement and Crushed "Bats"

The Blast Furnace and Steel Plant,
Pittsburgh, Pa.

Gentlemen—I was much interested in an article in your new "Brick Mason" section in your February issue, signed by the initials G. S. G. In his article, G. S. G. spoke of the advisability of using a mix of high temperature cement and crushed firebrick bats for patching. G. S. G. gives the impression that a

plastic mix of this sort is good only for patching. I hasten to correct G. S. G., for this is far from true.

In our own plant manufacturing taps, dies and forgings, we have been using a plastic refractory for about four years, not only for patching, but for the complete lining of furnaces. We have used it to such an extent that it has taken the place of firebrick altogether. We have found it far superior to any firebrick we have ever used.

Of course, the biggest advantage over firebrick is the longer life of the plastic material. The plastic does away with the weak joints of firebrick construction altogether. It gives a furnace lining that is like a lining built of single brick. Consequently, a plastic will outlast laid-up firebrick of the best construction two to four times. At least that has been our experience.

Longer life is a big thing in a plant like ours, where the furnaces must be kept in production. The cost of making firebrick repairs is great enough, but sometimes it is negligible in comparison with the loss that results because the furnace has been removed from production.

Another big advantage of the plastic lining is the speed of installation. We have our own men make our repairs, and we find that they can install the plastic material much more speedily than they could make repairs with brick. One reason for this is that there is no cutting of brick to fit special shapes and no installation of special shaped tile. It's as easy to build a door arch with a plastic as it is to build a side wall. We have found that our men are able to do a much neater, accurate, workmanlike job with plastic than with firebrick and cement.

We also have been using a plastic for the manufacture of a stock of special shapes, such as door liners. It is ideal for this purpose. We use our own forms, and mold up the shapes. Then they can be baked out in the combustion chamber of the boiler, or in the core oven or heating furnace. Made in this way, special shapes are very economical and you always have them when you want them. One is made independent of the delays of firebrick manufacture.

On the strength of the efficiency and economical maintenance of this material in our plant, we gladly recommend it to anyone requiring a dependable refractory that is longer-lived than ordinary firebrick. And in contradiction to G. S. G., we recommend it for complete linings. I know of one plant with an 851-hp. boiler fired with a Taylor stoker at a continuous overload that has had a complete plastic lining in the furnace for over 18 months now with the lining still good for considerable more service.

However, I disagree with G. S. G. in another particular, and that is in the matter of a plant's attempting to manufacture its own plastic. When there are so many good plastics on the market I believe that this is unwise. I know that a plastic cannot be manufactured for as little as it can be purchased.

To make a few tons of plastic a year means the installation of costly equipment. A firebrick crusher is necessary, and some sort of mixer is needed. Mixing by hand is not satisfactory. The overhead cost of this equipment must be considered in the cost of a home-made plastic.

Even if the brick bats don't cost anything, there is a material cost for high temperature cement that must be given consideration. Cements cost four to

five cents a pound, and the manufacturers suggest a 50-50 mix. With a mix of only one-third cement, and granting a cost of $4\frac{1}{2}$ cents per pound for the cement, this brings the cost of high temperature cement for the mixture to $1\frac{1}{2}$ cents per pound of plastic. I can buy the best plastic obtainable made of high grade eastern clays for $1\frac{1}{2}$ cents per pound in carload lots, and for only a little more in smaller quantities. Thus it is seen that the amateurish home-made plastic actually costs more to manufacture than the best accurately-manufactured commercial plastic can be purchased for.

One must be very careful in manufacturing a plastic. If it is too dry it will not vitrify properly. If it is too wet steam will be generated in the refractory wall and the plastic will be cracked and will spall.

Care also must be taken in grinding the bats to see that they are ground neither too fine nor too coarse. If too fine, the wall will not have any physical strength. If too coarse, the pieces will not be properly bonded together. All in all, we prefer to make taps and dies and let the plastic manufacturers make the plastic.

It will be found that the plastic manufacturers have developed installation methods to a fineness at which the individual user of home-made plastic could never arrive. Installing a plastic is easy work, but there will be trouble if one is not familiar with the few simple directions.

Just one caution to those who do make their own plastic: Be careful of the high temperature cement you buy for the bond. Many of the air-set cements contain silicate of soda, incorporated to give a quicker set. This silicate lowers the fusing point to about 2800 deg. F., which means shorter furnace life, of course.

The safe way, we believe, is to buy a good plastic from a company that knows how to make it, and then follow the installation instructions given by their service engineer.

Very truly yours,

G. Mark Brubaker,

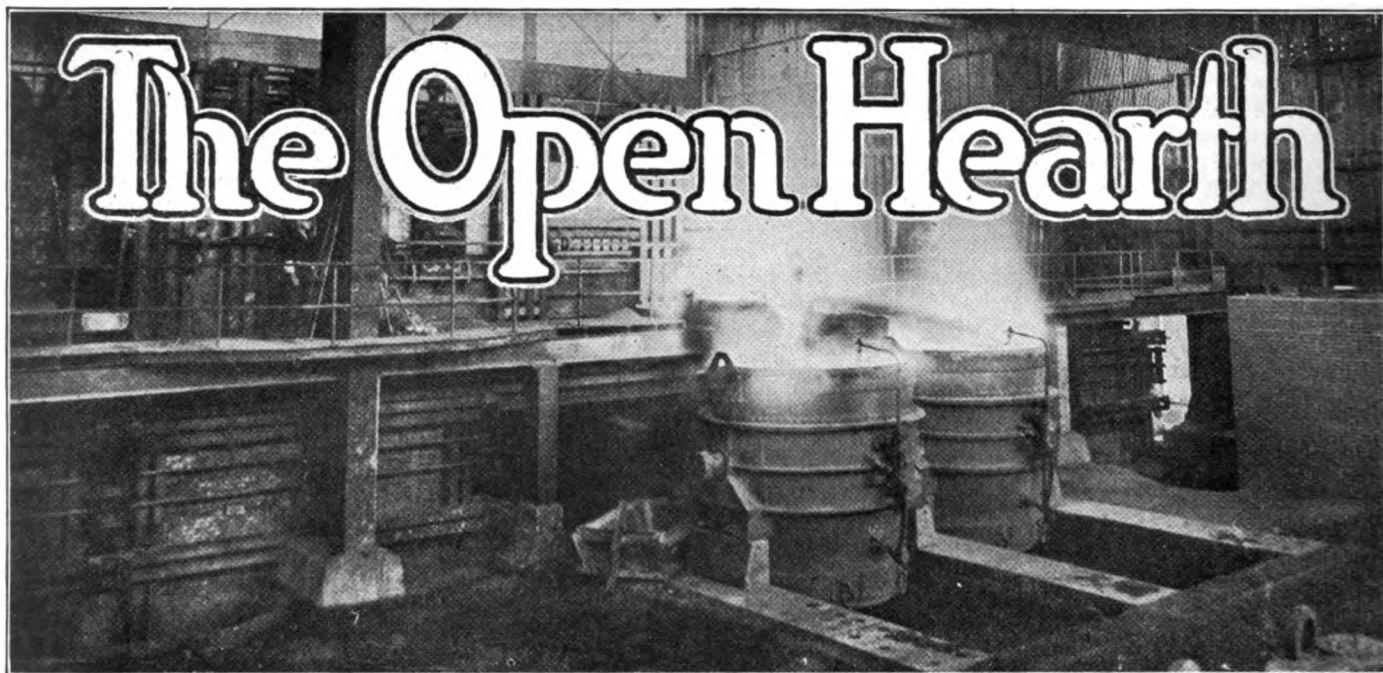
W. L. Brubaker & Bros. Company,

Millersburg, Pa.

Frank J. Donnelly has joined the New York office of Botfield Refractories Company, Philadelphia, Pa., and will cover the New Jersey territory under the direction of Charles C. Phillips, New York district manager. Mr. Donnelly will co-operate with users of Adamant fire brick cement and with every refractories user interested in prolonging brickwork life and in reducing repair costs.

The Mullite Refractories Company, Shelton, Conn., has incorporated with a capital of \$250,000 to make refractories, shapes, fire brick, furnaces, kiln lining, etc. Over 900 shares are owned by the Naugatuck Valley Crucible Company.

George A. Russ has joined the service staff of the Quigley Furnace Specialties Company, Inc., of New York, manufactureres of Hytempite, Quigley Refractory Gun, Triple-A Solutions, etc. He will cover the Central South and South Atlantic States. Making his headquarters at Atlanta, he will co-operate with all Quigley Agents throughout the South.



Edward R. Bishop, who for the last 15 years has been manager of the forge department of the Globe Malleable Iron & Steel Company, Syracuse, N. Y., has been appointed general manager of the company, succeeding Harry H. Elmer, who resigned March 5th.

* * *

Mr. Arthur Simonson was elected a vice president of the Falk Corporation at the annual meeting of the board of directors of the corporation, held on January 20, 1927. Mr. Simonson was born in Sheffield, England, and was educated at the Sheffield Technical School. He served his apprenticeship at the works of Edgar Allen & Co., Ltd., Sheffield, in the steel foundry department. Mr. Simonson was for some years general foundry superintendent of Wm. Wharton, Jr., & Company, Inc., Philadelphia, Pa., but since 1910 he has been connected with the Falk Corporation in various capacities in the steel foundry, and as sales manager of the steel foundry department since 1916.

* * *

G. N. Bull, formerly with the Worthington Pump & Machinery Company in their Washington, D. C., office, has been made district manager of the New York office of the Lincoln Electric Company. C. S. Freeman, formerly in charge of the Lancaster office, has been transferred to the Buffalo office and made district manager. S. W. Shultz, formerly of the Philadelphia office, has been put in charge of the Lancaster office. F. J. Pfister, formerly of the Buffalo office, has been transferred to the Philadelphia office.

* * *

Joseph G. Worker has been appointed general sales manager and a member of the board of directors as announced by the American Engineering Company, of Philadelphia. Mr. Worker assumes his new duties with more than 20 years' experience in engineering and sales work for the American Engineering Company. He is a graduate of the University of Illinois with the degree of B.S. in Mechanical Engineering, a member of the American Society of Mechanical Engineers and a former president of the Stoker Manufacturers' Association. He is widely known as a writer

of articles on combustion engineering and co-author of a work on mechanical stokers. For 15 years, Mr. Worker was associated with the Westinghouse companies and for the last five years of this period was manager of the Stoker Section of the Westinghouse Electric & Mfg. Company at East Pittsburgh.

* * *

L. Kemper has tendered his resignation as treasurer of the Otis Steel Company and as vice president and treasurer of the Midland Steel Products Company, Cleveland. Gordon Stoner, secretary of the Midland company and manager of its Detroit plant, will succeed him as vice president of the Midland organization, but will remain at the Detroit plant. H. F. Kulas succeeds Mr. Stoner as secretary of the Midland company and S. C. Conrad succeeds Mr. Kemper as its treasurer. At the Otis plant G. A. Paine, assistant treasurer, will discharge the treasurer's duties.

* * *

W. C. Stripe, former district manager of the Pittsburgh office of the Combustion Engineering Corporation, has been placed in charge of the Corporation's Publicity Department with headquarters in New York City. J. C. Ten Eyck succeeds Mr. Stripe as district manager. The Pittsburgh offices of the Combustion Engineering Corporation are in the First National Bank Building.

* * *

George W. Llewellyn has been appointed district sales manager in Detroit and the State of Michigan for the Seneca Iron & Steel Company, Buffalo. He was recently Detroit district manager for the Thomas Sheet Steel Company, Niles, Ohio.

* * *

John Drewson, recently superintendent of the Hazlewood by-product coke plant, Jones & Laughlin Steel Corporation, Pittsburgh, has become identified with the Koppers Company, Pittsburgh. Before being affiliated with the Jones & Laughlin organization in 1919, he was with the Corrigan-McKinney Steel Company, Cleveland, and prior to that, with the Woodward Iron Company, Woodward, Ala.



W. S. Getchell has tendered his resignation as superintendent of the fuel department of the Colorado Fuel & Iron Company, Denver, to accept the position of general manager of operations of the Alamo Coal Company, Oakdale Coal Company and Barbour Coal Company.

To Our Readers:

The Personals and News Events Department strives to present, each month, a variety of interesting happenings in the industry. Our readers in the hundreds of steel plants throughout the country mail us items covering events of interest, such as changes that have occurred or are contemplated in department or plant management, new machinery and equipment being installed, and occurrences in the plants, etc.

In fact, such an interesting variety of happenings reach us from regular readers that it is our purpose to encourage our thousands of "Blast Furnace and Steel Plant" subscribers by inviting them to send us each month features that may be of interest.

Items should be limited to 50 or 100 words, with full names of the individuals concerned. "The Blast Furnace and Steel Plant" desires to serve its readers, and enlarge its scope of usefulness to those engaged in the steel industry. Address all communications to the Editor.

Cordially,

THE BLAST FURNACE AND STEEL PLANT.

Percival S. Andrews, superintendent of the Wire Village Works of the Wickwire-Spencer Steel Company, Inc., at Spencer, Mass., has resigned to accept the position of general manager of the Wheeldon Wire Company, West Brookfield, Mass. Mr. Andrews has been with the Wickwire-Spencer Company for 26 years.

* * *

Felix Kremp has assumed the position of assistant general sales manager for the Braeburn Alloy Steel Corporation, Braeburn, Pa. He formerly was metallurgist for the Anchor Drawn Steel Company and Atlas Alloy Steel Corporation.

C. V. Lally, lately with the sales organization of the National Tube Company for the past 17 years, has been appointed general manager of sales of the Pittsburgh Steel Products Company, Pittsburgh, manufacturer of seamless steel boiler tubes, mechanical tubing and oil country goods, a subsidiary of the Pittsburgh Steel Company. Richard R. Harris has resigned as general manager of sales of the Pittsburgh Steel Company and subsidiaries. Mr. Harris is retiring from active business. George F. Jones will continue as manager of sales of the Pittsburgh Steel Company.

* * *

W. W. Holloway was chosen a director of the Wheeling Steel Corporation, Wheeling, W. Va. He fills the vacancy caused by the death of his father.

* * *

W. A. Maxwell, Jr., at present general superintendent of the Indiana Harbor Works of the Inland Steel Company will, on May 1, assume the position of manager of production for the Colorado Fuel & Iron Company. Mr. Maxwell for many years was superintendent of open hearth at the Homestead plant of the Carnegie Steel Company. He left this position to accept that of assistant general manager of the Cambria plant of the Midvale Steel & Ordnance Company at Johnstown, Pa. He is a graduate of the Pennsylvania State College.

* * *

L. C. Wilson, for 12 years sales engineer for various instrument companies, has been appointed representative in the Pittsburgh district for the Brown Instrument Company.

* * *

Charles M. Schwab, chairman of the Bethlehem Steel Corporation, returned March 14 from a trip to Europe.

Correction

In our March issue James Criswell was mentioned as resigning from the Arrowhead Iron Works and becoming affiliated with the Blaw-Knox Company. The name should have been John C. White instead of James Criswell.

TRADE PUBLICATIONS

Midwest Air Filters, Inc., Bradford, Pa., has issued two leaflets covering various uses of air filters. These filters are useful for removing the dust from air before it passes into compressors, combustion engines, etc. Other applications are in buildings for public gatherings, and where circumstances demand air free from particles of foreign matter.

* * *

The Compressed Gas Manufacturers' Association is distributing the 1926-1927 Membership Directory. In this directory a classified list of products manufactured by the members is presented. The publication should appeal to those interested in welding and cutting.

* * *

The American Telephone & Telegraph Company's report to the stockholders has been placed in the mails. The chronology covers the period from 1876 to the present, while the main report presents, in a very interesting manner, the scope of the company's activities and the progress in 1926. An especially interesting feature is a description, with an illustration, of the trans-Atlantic telephone service recently inaugurated. Sixty per cent of the world's telephones are in the United States.

* * *

The International Nickel Company, of 67 Wall Street, New York City, has published a pamphlet entitled "100 Years of Steel Improvements." It deals with the development of nickel alloy steel, which was one of the first alloys to be placed in service. Stodart and Faraday, by numerous experiments in 1822, discovered the enhanced properties of steel, to which nickel had been added. The International Nickel Company has prepared a special series of bulletins dealing with nickel alloy steels. These bulletins are sent at regular intervals to a large list of steel producers, engineers, metallurgists, societies, etc.

* * *

The Bureau of Standards has issued a report of the Building Code Committee under the title "Recommended Building Code Requirements for Working Stresses in Building Materials." The report proper covers 10 pages, whereas 43 are required for the appendix. This booklet is a clear, comprehensive treatise on building construction, which should prove of value to those desiring such information.

COMING MEETINGS

April 18-23—Oil Power Week. Meetings in all leading centers throughout the United States, on subjects of oil-engine fuels, engine design, operation, economics, trends, research problems, etc.

* * *

April 25-26—American Society of Mechanical Engineers. First national meeting of Aeronautic Division, Buffalo.

* * *

April 27-29—American Welding Society. Annual meeting at Engineering Societies Bldg., New York.

M. M. Kelly, 33 West Thirty-ninth Street, New York, is secretary.

* * *

April 28-30—American Electrochemical Society. Spring meeting at Benjamin Franklin Hotel, Philadelphia. Colin G. Fink, Columbia University, New York, is secretary.

* * *

May 12-14—American Gear Manufacturers' Association. Eleventh annual meeting at Hotel Hayes, Jackson, Mich. T. W. Owen, 2443 Prospect Avenue, Cleveland, is secretary.

* * *

May 18-19—American Refractories Institute. Spring meeting at Hotel Traymore, Atlantic City, N. J. M. C. Booze, 2202 Oliver Bldg., Pittsburgh, is secretary.

* * *

May 19-20—American Society for Steel Treating. Spring sectional meeting at Milwaukee. W. H. Eisenmann, 4600 Prospect Avenue, Cleveland, is secretary.

* * *

May 21—National Association of Foremen. Fourth annual convention at Cincinnati Zoo, Cincinnati. E. H. Tingley, 1249 U. B. Bldg., Dayton, Ohio, is secretary.

* * *

May 23-26—American Society of Mechanical Engineers. Spring meeting at White Sulphur Springs, W. Va. Calvin W. Rice, 29 West Thirty-ninth Street, New York, is secretary.

* * *

May 25-26-27—The fourteenth annual convention of the Foreign Trade Council at Detroit, which promises to be one of the most profitable and outstanding business conventions held in America this year.

Notable Mileage Record for Hyatt Bearings

It is rather unusual for a railroad car to run 300,000 miles on one set of journal bearings. Yet this is the mileage to date of a 12-wheel coach on the Chicago, Milwaukee & St. Paul R. R.

Hyatt Roller Bearings in four-motion boxes are used on all axles. A recent check-up on bearings showed them to be in perfect condition, free from wear or other signs of destruction.

It is interesting to note strides made in the application of roller bearings to gas rail cars and high speed electric railways. As an example a new subway under construction in an Eastern city will soon place into operation a 10-car train so equipped, and will no doubt go in extensively for roller bearings if this train "delivers" as expected.

One of the most important assets of roller bearings in railroad service is their low starting torque. Translated in terms of utility, a locomotive that starts with effort a 10-car train equipped with plain bearings, can start twice that number equipped with roller bearings.

From this standpoint it may be readily seen that roller bearings for short haul service actually promote faster schedules.

Another important betterment involves lubrication. Weekly check up on the oil level with addition of about a half gill of lubricant is the only requirement of roller bearings. Contrast this to perpetual oiling inherent with brass—repacking of waste—and replacing lost box lids.

NEWS OF THE PLANTS

The Annual Report of The Timken Roller Bearing Company for the year ending December 31, 1926, shows net profits from sales, with other net income, of \$8,474,103.00, after ample reserve for depreciation and after reserve for United States Income Taxes. Excerpts from Mr. H. H. Timken's report to stockholders are of interest to users of industrial machinery:

"Timken Bearings are now used extensively in some 300 different kinds of machinery, in many instances performing service heretofore thought impossible of any anti-friction bearing.

"During 1926 we completed our experimentation on three new types of Timken Bearings and began to successfully introduce them in the trade:—a line of very large bearings for heavy duty in steel mills, rolling mills, sugar mills, cement mills, etc., the bearings ranging in size up to 35 inches in diameter; a line of 'all thrust' bearings which are rapidly being adopted in special machinery such as valves, pivots, jacks, crane hooks, oil well swivels, etc.; and a line of double bearings, self contained, for certain types of electric motors, turbines, pumps, etc.

"During 1927 we profitably sold approximately double the tonnage of electric steel sold during the previous year. We are just completing a very substantial addition to our steel mills, costing about \$1,500,000.00, of which amount \$900,000.00 was spent in 1926. The additional plant will consist of one 90-ton Basic Open Hearth Furnace, two 15-ton and one 7-ton Electric Furnaces, and the necessary auxiliary equipment. This additional melting capacity will enable us to take care of the increasing market for Timken Steel.

"Our first large order for passenger car bearings was obtained in the fall of 1926 from the Chicago, Milwaukee and St. Paul Railroad for 63 new Pullman cars and 64 cars of Chicago, Milwaukee and St. Paul ownership, coaches, dining cars, baggage cars, etc., making twelve complete trains. This will be the first time in the history of an American railroad that complete transcontinental trains will be equipped with roller bearings."

* * *

American Mond Nickel Corp., Clearfield, Pa., is moving its headquarters to Pittsburgh, it is announced by Grant B. Shipley, of the board of directors. Quarters have been taken in the Century building until a permanent location is decided upon. The plant will remain in Clearfield.

* * *

The Chambersburg Engineering Company, of Chambersburg, Penna., manufacturers of forging hammers, presses, riveters, pneumatic and hydraulic machinery, announce the appointment of Huey & Philp Hardware Company, of Dallas, Texas as their exclusive agents in Texas and Oklahoma.

* * *

The Standard Seamless Tube Company of Ambbridge, Pennsylvania, has contracted with the Chapman-Stein Furnace Company of Mt. Vernon, Ohio, for rebuilding another of their bar mill furnaces. The

contract includes producer gas flues, headers and platforms, as well as the twenty ton per hour recuperative furnace.

When completed, this furnace will be the sixth furnace of this type which the Chapman-Stein Furnace Company has built for this Company.

* * *

The La Cœur Iron Works, of Long Island City, has adopted a cooperative group insurance program providing its employes with more than \$58,000 of life insurance, the advantages of a visiting nurse service. In addition to the life insurance, liberal weekly benefits are provided under the terms of a health and non-occupational accident policy.

The group plan, underwritten by the Metropolitan Life Insurance Company, is arranged on a cooperative basis. By this method of payment, the employer contributes liberally towards the cost of the insurance.

* * *

Dominion Alloy Steel Corp., Sarnia, Ont., W. B. Boyd, president, has completed installation of a continuous mill and will proceed at once to add a black sheet mill for which raw material will be available from the new rolling mill. The company marketed 10,000 tons of galvanized sheets in 1926, which is an unusual tonnage of this mill.

* * *

Announcement is made of a new Canadian company which will concentrate on the manufacture of well known power plant equipment, and which has purchased the plant of the former Engineering & Machine Works of Canada, Ltd., at St. Catharines, Ont. The new corporation will be known as the Canadian Power Specialty Company, Ltd., with main office at the works, and sales offices in Ottawa, Toronto, Montreal, Moncton and North Bay. G. R. Cottrelle of the Canadian Bank of Commerce, Toronto, and G. B. Greene of the General Supply Company of Canada, Ltd., Ottawa, were chiefly responsible for the formation of the new company, and for arrangements under which it is to manufacture and sell Foster power plant equipment in the Dominion. In addition to Foster superheaters, economizers, water backs, furnace surfaces and tubular oil stills, the line includes Aero Unit Coal Pulverizers, which were the first unit coal pulverizers made on the American continent. The plant at St. Catharines includes foundry, pattern shop, machine shop, boiler shop, erecting shop, office, etc., and has a steady trade of pulp and paper mill machinery, and special machine work to meet the requirements of manufacturers without their own shop. The plant is on the Welland Canal and served by two railway sidings, so that it is centrally located and in close touch with large sources of supplies and a good labor market.

* * *

D. B. Baird, for a number of years superintendent of the blast furnaces of the Wheeling Steel Corporation, LaBelle, Ohio, plant, has resigned after a service dating back years.

The Blast Furnace *(and)* Steel Plant

Member of the Audit
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PITTSBURGH, PA., APRIL, 1927

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